



Department of Aerospace Engineering
and Applied Mechanics
University of Cincinnati

COMPUTER PROGRAM FOR THE
ANALYSIS OF THE CROSS FLOW IN A
RADIAL INFLOW TURBINE SCROLL

BY

A. HAMED, S. ABDALLAH AND W. TABAKOFF

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16 Abstract This report describes and explains the computer program that has been used to solve the governing equations of the potential flow in the cross-sectional planes of a radial inflow turbine scroll. The derivation of the governing equations and the description of the numerical solution can be found in NASA CR (to be assigned) Report entitled "Analysis of the Cross Flow in a Radial Inflow Turbine Scroll". A list of the main program, the subroutines, and typical output example are included. ORIGINAL PAGE IS OF POOR QUALITY					
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SUMMARY

This report describes and explains the computer program that has been used to solve the governing equations of the potential flow in the cross-sectional planes of a radial inflow turbine scroll. The derivation of the governing equations and the description of the numerical solution can be found in NASA CR (to be assigned) Report entitled "Analysis of the Cross Flow in a Radial Inflow Turbine Scroll."

A list of the main program, the subroutines, and typical output example are included.

COMPUTER PROGRAM

The Fortran computer program, which is used to solve the equations of potential flow in the cross-sectional plane of the centrifugal machine's volute or scroll will be described and listed. The input data to this program includes information about inlet flow properties, the cross section geometry, and its corresponding boundary conditions, which are shown in Figures 1 and 2. The maximum allowable number of mesh lines in the x and y directions are 50 and 30, respectively. The program output includes an echo print of the input data. At each grid point, the value of the potential function, the velocity components in the x and y directions, as well as the magnitude of the velocity vector and the angle it makes with the x axis are printed. Additional output is obtained in the form of plots of constant potential function contours, and arrows showing the direction of the velocity in the axial-radial plane.

The logical relations of the main program and subroutines are shown in Figures A-1, A-2 and A-3. A brief description of the main program and subroutines is given below.

Main Program:

The main program is primarily used to call the subroutines. The logic flow diagram is illustrated in Figure A-1.

Subroutine IRL(J):

It is called from the main program and the subroutines to determine IL(J) and IR(J), the first and last interior mesh points for the scroll cross-section at a given J mesh line (see Fig. A-4).

Subroutine INTPL(I):

It is called from the main program and the subroutines to determine JL(I) and JU(I), the lower and the upper interior mesh points for the scroll cross-section at a given I mesh line (see Fig. A-4).

Subroutine MESH(I,J):

It is called from the main program and the subroutines to identify the interior mesh point neighbors, calculate the coeffi-

icients of the five points Laplace difference operator, and to determine the most recent values of the potential functions at the interior mesh points.

Subroutine SHABAN:

It is called from the main program, to determine the source strength at every mesh point $F(I,J)$, for a given mass flow rate and through flow velocity profile. The logic flow diagram is illustrated in Figure A-2.

Subroutine AWATEF:

It is called from the main program to determine the values of the potential function, at each grid point. The logic flow diagram of this subroutine is illustrated in Figure A-3.

Subroutine BCSI(I):

It is called from the subroutine AWATEF, to determine the values of the potential function at the boundary points on a given I mesh line.

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Subroutine BCSJ(J):

It is called from the subroutine AWATEF, to determine the values of the potential function at the boundary points on a given J mesh line.

Subroutine HVVEL:

It is called from the main program to determine the values of the velocity components in the x and y directions, at every mesh point.

Subroutine ABDLAH:

It is called from the main program to calculate the magnitude of the velocity vector in the axial radial plane and the angle it makes with the x-axis.

Subroutine HOSNY:

It is called from the subroutine SHABAN to calculate the flow density at each grid point.

Subroutine PLTISO:

It is called from the main program to plot the contours of constant potential function.

Additional library subroutines, namely, PLOT (X1, X2, X3), SYMBOL (Y1, Y2, Y3, Y4, Y5, Y6), and ENDPLT, are called from the main program, and used in the plotting of both the potential contours and the velocity direction.

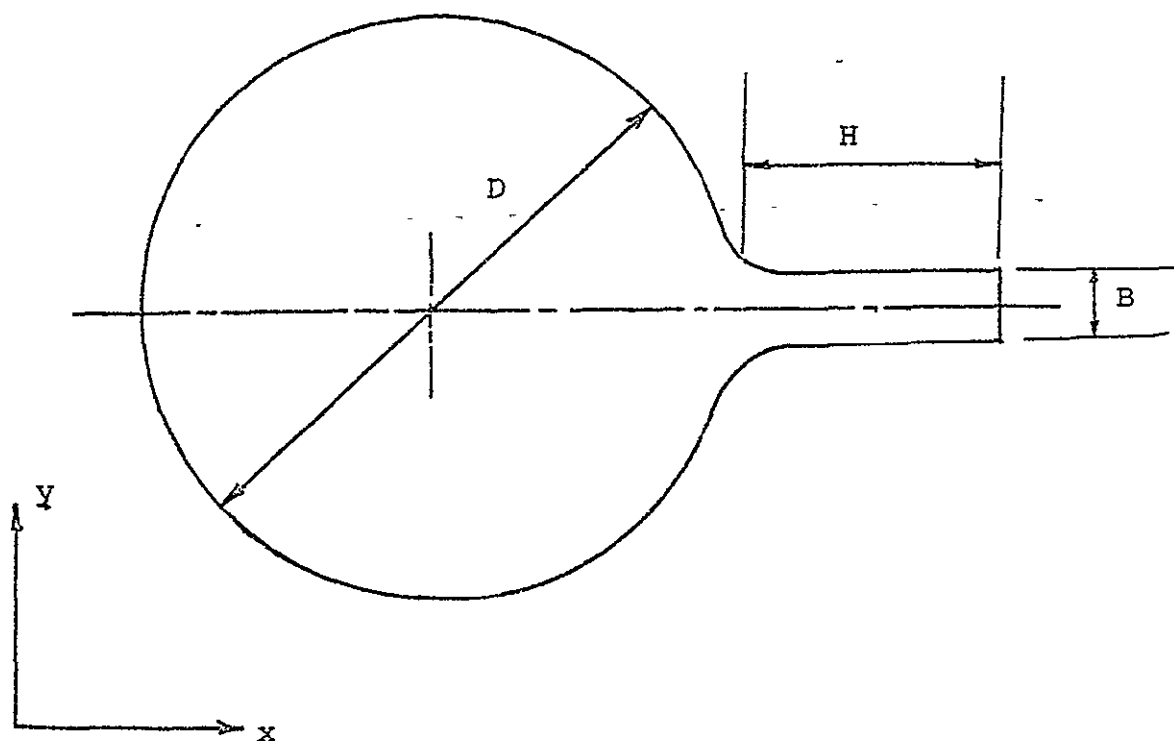


FIG. 1. SYMMETRIC SCROLL CROSS SECTION

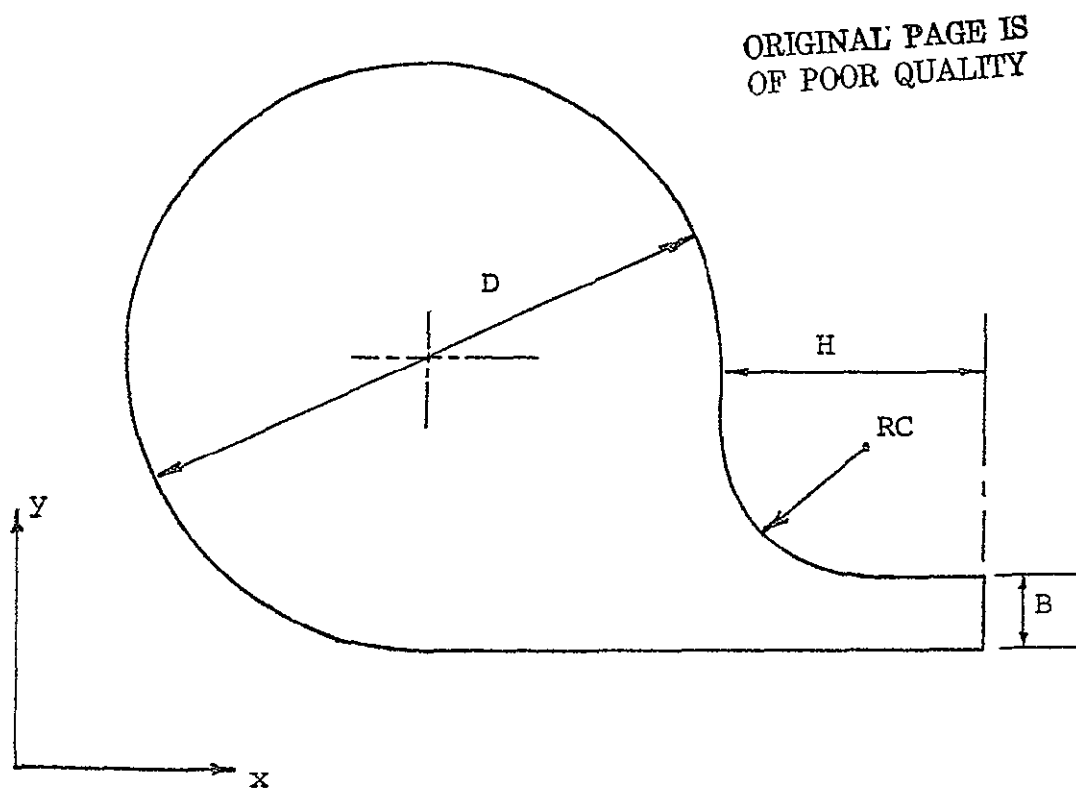


FIG. 2. NON SYMMETRIC SCROLL CROSS SECTION.

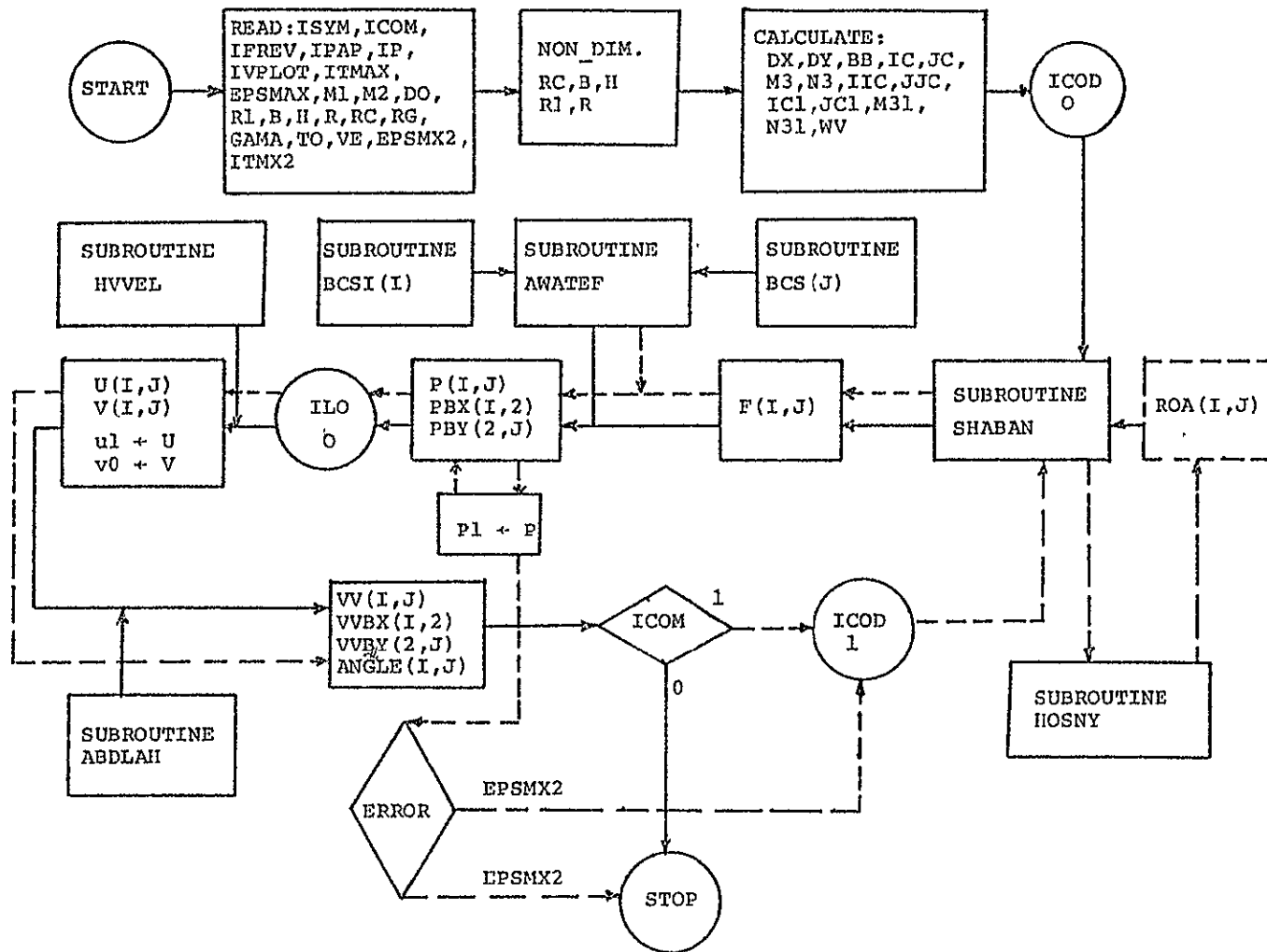


FIGURE (A-1) MAIN PROGRAM

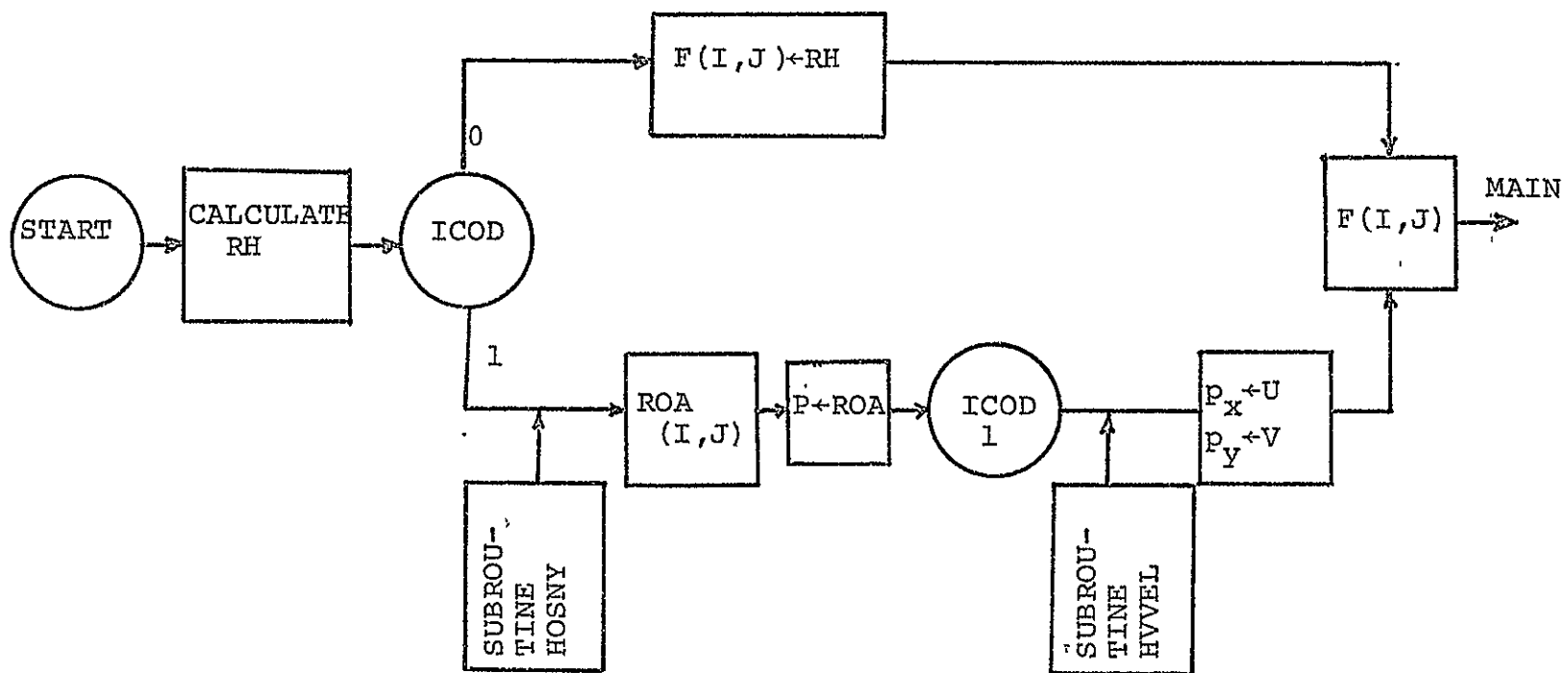


FIGURE (A-2) SUBROUTINE SHABAN

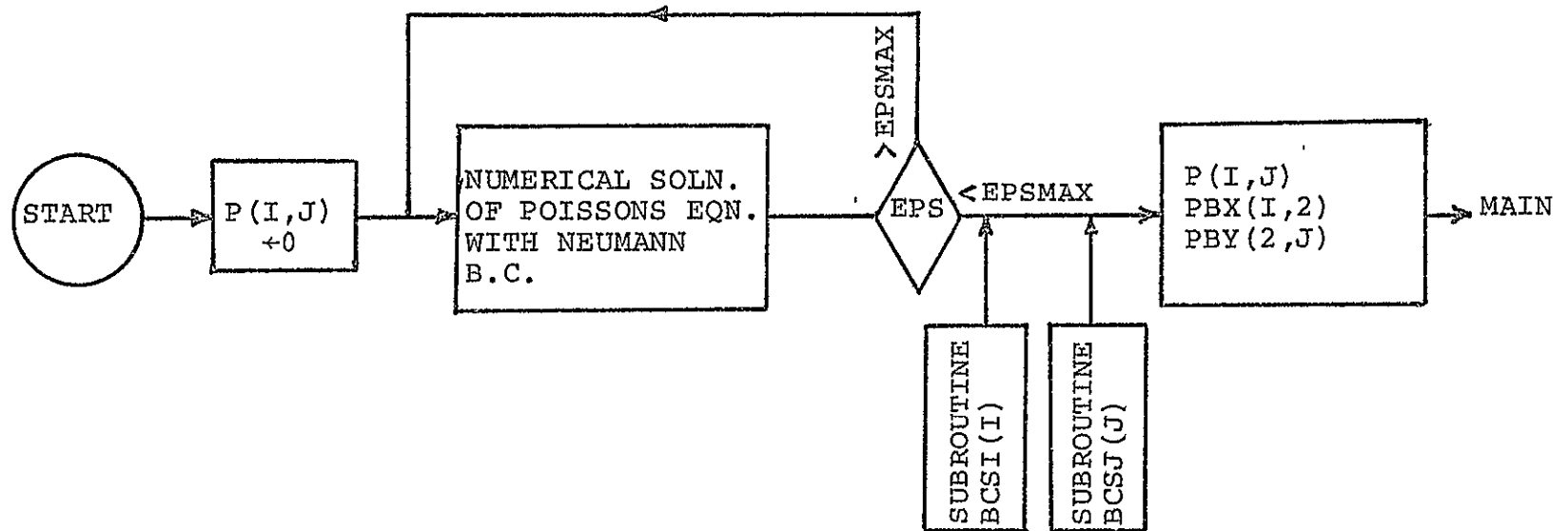


FIGURE (A-3) SUBROUTINE AWATEF

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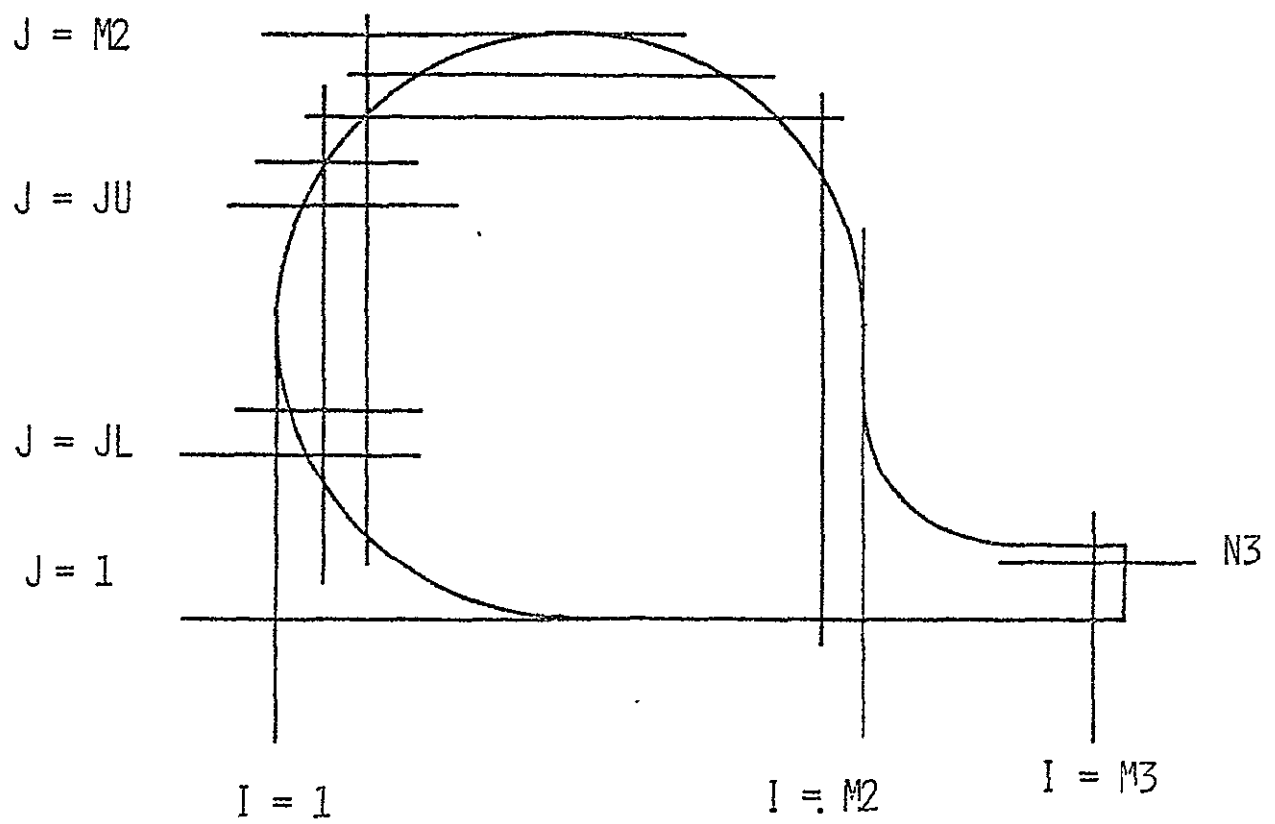


FIGURE (A-4)

DEFINITION OF SYMBOLS AND FORTRAN LISTING

<u>Symbols</u>	<u>Description</u>
B	Width of the scroll exit (Figs 1, 2).
DO	Scroll inlet diameter.
EPSMAX	The largest tolerable value of the square of the sum of the absolute values of the deviations of $\phi_{i,j}$ from their previously computed values.
F	Vector containing the values of Poisson's source strength at each grid point.
GAMA	Ratio of specific heats.
H	Length of scroll exit nozzle, Figs. 1 and 2.
ICOM	Parameter to control type of calculations. ICOM = 0 for incompressible flow and ICOM = 1 for compressible flow.
IFG, IPAP, IFREVO	Parameters to control the mass source distribution (i.e., the type of through flow velocity profile).
IP	Frequency of intermediate printout.— Solutions are printed after every IP iteration.
IPLT	Number of contours in the output plot for the potential velocity.
ISYM	Parameter to control type of scroll cross section. For symmetric cross-section ISYM = 1, and for unsymmetric cross-section ISYM = 0.
ITMAX	Maximum allowable number of iterations.
IVPLOT	Parameter to control plotting of program output, IVPLOT = 1, a plot is prepared; if IVPLOT = 0, no plot is prepared.
M1,M2,M3,N3	Number of mesh lines of the scroll cross-section, Fig. (A-4).

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<u>Symbols</u>	<u>Description</u>
P	Vector containing the values of the potential function ϕ at all grid points.
PBX,PBY	Vectors containing the values of ϕ on the scroll boundaries.
$P_i (i=0,1,2,3,4)$	The values of the potential function at the standard five points Laplace difference operator.
R	Radius of the scroll cross-section equal $D/2$, Figs. 1 and 2.
RC	Radius of exit portion of the unsymmetric cross-section, Fig. 3. (Ref. 1)
Rl	Radius of scroll exit .
RG	Gas constant.
ROA	Vector containing the values of the density at all grid points.
ROBX,ROBY	Vectors containing the values of the density at the boundary points.
THETA	Vector containing the values of the angle between the velocity vector $\bar{V}$, and the x-axis at each grid point.
TO	Stagnation temperature
U,V	Vectors containing the values of the flow velocity, components in the x and y directions, respectively.
UBX,UBY	Vectors containing the values of the velocity component in the x-direction at the boundary points of all I and J mesh lines.
VBX,VBY	Vectors containing the values of the velocity component in the y-direction at the boundary points of all I and J mesh lines.
VE	Scroll exit velocity in radial direction.

<u>Symbols</u>	<u>Description</u>
VISOBR	Numerical values of the velocity potential contours to be plotted as output.
VV	Vector containing the absolute values of the velocity vector $\bar{V}$, at each grid point.
VVBX,VVBY	Vectors containing the absolute values of the velocity vector $\bar{V}$, at the boundary points for each I and J mesh lines, respectively.
WO,WOP	Successive relaxation factors. WO for interior mesh points, and WOP for the points adjacent to the boundaries.

PROGRAM LISTING

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```

IMPLICIT REAL*8 (A-H,O-Z)
DIMENSION X(50,21),Y(50,21),VAR(50,21),VRR(50,21)
COMMON /ONE/ V1
COMMON /TWO/ ILJ,IWR,ISYM,IPAP,ICD,IP,ICOM
COMMON /THREE/ RI,RF,IFREV0
COMMON /FOUR/ R,RC,I,B,UX,DY,B1,BB
COMMON /FIVE/ M1,M2,IC,JC,IIC,JJC,M3,N3
COMMON /SIX/ S1,S2,S3,S4,P1,P2,P3,P4,JL,JU,IL,IH
COMMON /SEVEN/ P(50,30),PBX(2,30),PBX1(50,2),PP(50,30),PBY1(2,30),
1 PBX1(50,2),F(50,30)
COMMON /EIGHT/ U(50,30),V(50,30),UBX(50,2),VBX(50,2),
1 UBY(2,30),VBY(2,30),U1(50,30),V0(50,30),UBX1(50,2),
1 VBX1(50,2),UBY1(2,30),VBY1(2,30),VV(50,30),ANGLE(50,30)
COMMON /NINE/ M21,IC1,JC1,M11,N31,IC2
COMMON /TEN/ RG,GAMA,TG,WV,VE
COMMON /ELEVEN/ EPSMAX,EPSM2,W0,WOP,ITMAX,ITMX2
COMMON /TWELVE/ ROA(50,30),ROBX(50,2),ROBY(2,30)
COMMON /THIRTEEN/ VVBX(50,2),VVBX1(2,30),ANGL1(50,2),ANGL2(2,30)
CALL UNDFLW
C
CC CALCULATE 2-DIM. POTENTIAL FUNCTION & VELOCITY VECTOR V IN THE
CC SCROLL CROSS SECTION FOR INCOMP. & COMP. FLUX
C
CC READ INPUT DATA *****
C
READ(5,102) RG,GAMA,TG,VE
READ(5,100) M1,M2,D0,R1,B,H,R,RC
READ(5,101) ICOM,ISYM,IFG,IPAP,IFREV0
READ(5,200) ITMAX,EPSMAX,W0,WOP
READ(5,7177) IP,IPLOT,IP_T
C
C
ITMX2=ITMAX
EPSM2=EPSMAX
C
C
V1=1.0D0
RC=RC/(2*R)
B=B/(2*R)
IF (ISYM.EQ.1) B=B/2.0D0
H=H/(2*R)
P0=R1/D0
R1=R1/(2*R)
AV=16.0D0*R0*B*R/D0
IF (ISYM.EQ.1) WV=2.0D0*WV
RF=2.0D0*R
R=R/(2*R)
KATIO=(R1+H+R)/(2.0D0*R)
DX=2*R/(M1-1)
DY=2*R/(M2-1)
IF (ISYM.EQ.1) DY=R/(M2-1)
B1=DX/DY
BB=B1*B1

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M21=M2-1
IC=(M1+1)/2
JC=(M2+1)/2
IF(1SYM.EQ.1) JC=1
N3=(B/DY-0.0001000)+1
V3=((R+R+1)/DX-J.0001000)+1
IC1=IC-1
JC1=JC-1
IC2=IC+1
M11=M1-1
N31=N3-1
M31=M3-1
IF(1SYM.EQ.1) GO TO 555
IIC=(RC/DX-0.0001000)+M1
JJC=((B+RC)/DY-0.0001000)+1
C
555 DO 12 I=1,M3
DO 12 J=1,M2
ANGLE(I,J)=0.000
ROA(I,J)=1.000
ROBX(I,1)=1.000
ROBX(I,2)=1.000
ROBY(1,J)=1.000
ROBY(2,J)=1.000
F(I,J)=0.000
12 CONTINUE
IF(1FG.EQ.0) GO TO 5557
DO 5552 I=2,M31
CALL INTPL(I)
5552 READ(5,5553)(F(I,J),J=JL,JU)
5557 CONTINUE
C
CC WRITE INPJT DATA FOR CHECK *****
C
WRITE(6,1313)
WRITE(6,405) RG,GAMA,TD,VE
WRITE(6,340) M1,M2,M1,B,H,RC,RF,D0
WRITE(6,310) ICOM,1SYM,1FS,IPAP,IFREVO
WRITE(6,320) ITMAX,EPHMAX,W0,WOP
WRITE(6,330) IP,1VPL0T,1PLT
WRITE(6,301) DX,DY,IC,JC,M3,N3
C
CC SOLVE FOR INCOMP. FLOW *****
C
IWR=0
ICOD=0
CALL SHABAN
CALL AWATEF
ILO=0
CALL HVVEL
CALL ABDLAH
IF(ICOM.EQ.0) GO TO 818
C

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CC SOLVE FOR COMP. FLOW *****

```

C
  DO 2 I=2,M3
    CALL INTPL(I)
    DO 2 J=JL,JU
      PP(I,J)=1.000
      VEO=VE
      IT=0
      IWR=1
717  IT=IT+1
      ERROR=0.000
      ICOD=1
      VE=VEO/RUBY(2,2)
      CALL SHA3AN
      CALL AWATEF
      ILD=0
      CALL HVVEL
      CALL ABD_AH
      DO 7 I=2,M3
        CALL INTPL(I)
        DO 7 J=JL,JU
          SAV=PP(I,J)
7      ERROR=ERROR+DABS(P(I,J)-SAV)*#2
          DO 111 I=2,M3
            CALL INTPL(I)
            DO 111 J=JL,JU
111      PP(I,J)=P(I,J)
            DO 112 I=2,M3
              DO 112 J=1,2
112      PBX1(I,J)=PBX(I,J)
              DO 114 J=2,M21
                DO 114 I=1,2
114      PBY1(I,J)=PSY(I,J)
              IF(IT.GE.ITMX2) GO TO 919
              IF(ERROR.GE.EPSMX2) GO TO 717
919      WRITE(6,14)
          WRITE(6,407)
          DO 9 I=2,M3
8      WRITE(6,408) I,(P(I,J),J=1,M21)
          WRITE(6,151) IT,ERROR,VE
          WRITE(6,404)
          DO 40 J=1,M21
40      WRITE(6,400) J,(P(I,J),I=1,M3)
          IF(ISYM.EQ.1) GO TO 46
          WRITE(6,401)
          DO 42 I=2,M3
42      WRITE(6,402) I,(PBX(I,J),J=1,2)
          GO TO 45
46      WRITE(6,4005)
          DO 47 I=2,M3
47      WRITE(6,406) I,PBX(I,2)
45      WRITE(6,403)
          DO 44 J=1,M21

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44  WRITE(6,402) J,(PBY(I,J),I=1,2)
    IWR=0
    CALL HVVEL
    CALL ABDLH
818  CONTINUE
    IF(1VPLJT.EQ.0) GO TO 7007
C
CC PLOTTING OF THE FLOW DIRECTIONS *****
C
    ISKIP=1
    JSKIP=1
    DXD=0.25
    CALL BEGP_T
    ICPM=2
    ICP=1
    DO 59 I=1,M3
    DO 58 J=1,M2
    X(I,J)=(I-1)*DXD
    Y(I,J)=(J-1)*DXD
58  CONTINUE
59  CONTINUE
    WRITE(6,14)
    WRITE(6,5001)
    DO 62 I=1,M3
62  WRITE(6,20) (X(I,J),J=1,M2)
    WRITE(6,14)
    WRITE(6,5002)
    DO 64 I=1,M3
64  WRITE(6,20) (Y(I,J),J=1,M2)
    WRITE(6,14)
75  IF(1SYM.EQ.1) GO TO 76
    CALL PLOT(1.5,1.5,23)
    GO TO 77
76  CALL PLOT(1.5,3.5,23)
77  IUPODW=1
    SIZE=0.14
    1SYMBL=75
    IF(ICP.EQ.1) GO TO 11
    IF(ICP.EQ.2) GO TO 133
11  DO 50 I=2,M3
    DO 50 J=1,M2
    VRR(I,J)=270.0+ANGLE(I,J)
50  CONTINUE
    CALL PLOT(0.0,0.0,3)
    DO 501 I=2,M3
    CALL INTPL(I)
    DO 511 J=JL,JU
    XXC=X(I,J)
    YYC=Y(I,J)
    CALL SYMBOL (XXC,YYC,SIZE,18,VRR(I,J),-1)
511 CONTINUE
501 CONTINUE
    CALL PLOT (0.0,0.0,3)

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      ICP=ICP+1
      IF(ICP.GT.ICPM) GO TO 3
      CALL PAUSE
      CALL PAUSE
      GO TO 75
133 CONTINUE
C
CC CONTOURS PLOT
C
      DO 510 I=1,M3
      DO 510 J=1,M2
510  VAR(I,J)=P(I,J)
      DO 514 I=2,M3
      CALL INTPL(I)
      J1=JL-1
      J2=JU+1
      VAR(I,J2)=PBX(I,2)
      IF(ISYM.EQ.1) GO TO 514
      VAR(I,J1)=PBX(I,1)
514  CONTINUE
      DO 515 J=2,M21
      CALL IR_(J)
      I1=IL-1
      I2=IR+1
      VAR(I1,J)=PBY(1,J)
515  VAR(I2,J)=PBY(2,J)
      CALL PLOT (0.0,0.0,3)
      DO 222 IP_=1,IPLT
      READ(5,5) VISOSR
      CALL PLTISO(M21,ISYMBL,IUPOD%,SIZE,VISOSR,VAR,X,Y)
      CALL PLOT(0.0,0.0,23)
222  CONTINUE
      CALL PLDT (0.0,0.0,3)
3    CONTINUE
      CALL ENDPLT
7007 CONTINUE
5    FORMAT(F10.0)
14   FORMAT(141)
20   FORMAT(10(6X,'6.3'))
100  FORMAT(2I10,6F10.0)
101  FORMAT(5I10)
102  FORMAT(4F10.0)
151  FORMAT(20X,'ITCOM=',I5,'/',20X,'ERROR=',E20.9,'/',20X,'V EX=',E20.9)
200  FORMAT(I10,3F10.0)
301  FORMAT(20X,'DX   =',F10.5,5X,'DY   =',F10.5,5X,'IC   =',I10,'/',
1    20X,'JC   =',I10,' 5X,'V3   =',I10,5X,'V3   =',I10,'/')
310  FORMAT('/',20X,'ICUM =',I10,'/',20X,'ISYM =',I10,'/',20X,'IFG   =',
1    I10,'/',20X,'IPAD  =',I10,'/',20X,'IFREQ=',I10,'/')
320  FORMAT('/',20X,'ITMAX=',I10,'/',20X,'EPSMAX=',F10.8,'/',20X,'WD   =',
1    F10.5,'/',20X,'WDP   =',F10.5,'/')
330  FORMAT('/',20X,'IP   =',I10,'/',20X,'IVPLDT=',I10,'/',20X,'IPLT =',
1    I10,'/')
340  FORMAT('/',20X,'M1   =',I10,'/',20X,'M2   =',I10,'/',20X,'R1   =',F10.5

```

```

1    ,/,20X,'B    =' ,F10.5,/,20X,'H    =' ,F10.5,/,20X,'RC    =' ,
1    F10.3,/,20X,'D    =' ,F10.5,2X,'UNIT DIM.',/,20X,'UD    =' ,F10.5
1    ,2X,'UNIT DIM.',/)
400 FORMAT(//,7X,'J    =' ,12,/,10(5X,5015.6//))
401 FORMAT(//,15X,'I    ',5X,'PBX1',15X,'PBX2')
402 FORMAT(//,10X,14,5X,2(5X,D15.6))
403 FORMAT(//,15X,'J    ',5X,'PBY1',15X,'PBY2')
404 FORMAT(//,20X,'VALUES OF VELOCITY POTENTIAL P(I,J) FOR COMPRESSIBL
1E FLOW',/)
405 FORMAT(//,20X,'GAS CONSTANT =' ,F10.5,/,20X,'GAMA    =' ,F10.5
1    ,/,20X,'STAG. TEMP.    =' ,F10.5,/,20X,'RAD. EXIT VEL=' ,F10.5,/)
406 FORMAT(//,15X,14,10X,D15.6)
407 FORMAT(//,10X,'POISSONS SOURCE DIS. AT EACH GRID POINT',//)
408 FORMAT(//,7X,'I    =' ,110,/,4(8F10.5))
1313 FORMAT(//,10X,'INPUT DATA',//)
4005 FORMAT(//,20X,'I    ',5X,'PBX2',/)
5001 FORMAT(//,20X,'X-COORD. OF THE PLOTTING DOMAIN',//)
5002 FORMAT(//,20X,'Y-COORD. OF THE PLOTTING DOMAIN',//)
7177 FORMAT(3I10)
5553 FORMAT(8(F10.))
7177 FORMAT(3I10)
STOP
END

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      SUBROUTINE AWATEF
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /ONE/ V1
      COMMON /TWO/ ILJ, IWR, ISYM, IPAP, ICOD, IP, ICOM
      COMMON /THREE/ R, RC, Y, B, DX, DY, B1, BB
      COMMON /FOUR/ M1, M2, IC, JC, IIC, JJC, M3, N3
      COMMON /FIVE/ S1, S2, S3, S4, P1, P2, P3, P4, JL, JU, IL, IR
      COMMON /SIX/ P(50,30), PBX(50,2), PP(50,30), PSY1(2,30),
1     PBX1(50,2), F(50,30)
      COMMON /SEVEN/ M21, IC1, JC1, M11, N31, IC2
      COMMON /EIGHT/ EPSMAX, EPSM2, *O, *OP, ITMAX, ITMX2

C
C CALCULATE POTENTIAL VELOCITY DIST. IN THE SCROLL CROSS SECTION BY
C SOLVING POISSONS EQN. WITH NEUMANN B. C. THE ITER. METHOD IS S.O.R.
C
2     DO 1 I=1, M3
      DO 1 J=1, M2
1     P(I,J)=0.000
      ITER=0
15    ITER=ITER+1
      EPS=0.000
      DO 5 I=2, M3
        XX1=(IC-I)*DX
        X1=DABS(XX1)
        YY1=DABS(R*R-X1*X1)
        Y1=DSORT(YY1)
        CALL INTP_(I)
        DO 4 J=JL, JU
          W=W0
          W1=1.000-W
          WB=W/(2.000+2.000*BB)
          DD=1.000-WB*BB
          WB1=1.000-WB
          YY2=(JC-J)*DY
          Y2=DABS(YY2)
          XX2=DABS(R*R-Y2*Y2)
          X2=DSORT(XX2)
          SAVP=P(I,J)
          CALL IR_(J)
          CALL MESH(I,J)
          L11=1.000
          L33=1.000
          WB11=1.000-WB*L11
          WB12=1.000-WB*L33
          C24=1/(DY*DY*S2*S4)
          C13=1/(DX*DX*S1*S3)
          S24=1/(DY*DY*(S2+S4))
          S13=1/(DX*DX*(S1+S3))
          S1L=S13*L11
          S1K=S13*L33
          P11=L11*P1/S1
          P22=P2/S2
          P33=L33*P3/S3

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P44=P4/S4
IF(I.EQ.M1.AND.J.EQ.JU) GO TO 923
IF(I.EQ.I1.AND.J.EQ.JL) GO TO 86
IF(I.EQ.I1.AND.J.EQ.JU) GO TO 85
IF(I.EQ.I1) GO TO 90
IF(I.EQ.I2.AND.J.EQ.JL) GO TO 91
IF(I.EQ.I2.AND.J.EQ.JU) GO TO 92
IF(I.EQ.I2) GO TO 93
IF(J.EQ.JL) GO TO 94
IF(J.EQ.JU) GO TO 95
P(I,J)=(1.0D0-KUP)*P(I,J)+(KUP/(2+2*BB))*(L11*P1+L33*P3+
1 BB*(P2+P4)-F(I,J)*DX*DX)
GO TO 477
80 CONTINUE
IF(J.EQ.1) GO TO 81
PB1=Y2*B1*P(I,J+1)/X2
PB2=X1*P(I+1,J)/(B1*Y1)
CK1=(W*S1L*((1/S1)-Y2*B1/X2)+W*S24*((1/S4)-X1/(B1*Y1)))/(C13+C24)
IF(CK1.GT.0.9990D0.AND.CK1.LT.1.001) GO TO 16
CK=1.0D0-CK1
GO TO 17
16 CK1=CK1/W
CK=1.0D0-CK1
W1=0.0D0
W=1.0D0
17 CONTINUE
P(I,J)=(W1*P(I,J)+W*(S13*(PB1+P33)+S24*(P22+PB2)-F(I,J)/2)
1 /(C13+C24))/CK
GO TO 477
81 CONTINUE
P(I,J)=(W1*P(I,J)+W6*(2*BB*P2+P33-F(I,J)*DX*DX))/WB11
GO TO 477
85 CONTINUE
PB1=Y2*B1*P(I,J-1)/X2
PB2=X1*P(I+1,J)/(B1*Y1)
CK1=(W*S1L*((1/S1)-Y2*B1/X2)+W*S24*((1/S2)-X1/(B1*Y1)))/(C13+C24)
IF(CK1.GT.0.9990D0.AND.CK1.LT.1.001) GO TO 18
CK=1.0D0-CK1
GO TO 19
18 CK1=CK1/W
CK=1.0D0-CK1
W1=0.0D0
W=1.0D0
19 CONTINUE
P(I,J)=(W1*P(I,J)+W*(S13*(PB1+P33)+S24*(P44+PB2)-F(I,J)/2)
1 /(C13+C24))/CK
GO TO 477
90 CONTINUE
IF(J.GT.JC) GO TO 909
PB1=P(I,J+1)*Y2*B1/X2
CK1=(W*S1L*((1/S1)-Y2*B1/X2))/(C13+C24)
IF(CK1.GT.0.9990D0.AND.CK1.LT.1.001) GO TO 20
CK=1.0D0-CK1

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GO TO 21
20 CK1=CK1/W
   CK=1.000-CK1
   W1=0.000
   W=1.000
21 CONTINUE
   P(I,J)=(W1*P(I,J))+W*(S13*(PB1+P33)+S24*(P22+P44)-F(I,J)/2)
1   /(C13+C24))/CK
   GO TO 477
909 CONTINUE
   PB1=P(I,J-1)*Y2*B1/X2
   CK1=((W*S1L*((1/Y1)-Y2*B1/X2))/(C13+C24)
   IF(CK1.GT.0.999000.AND.CK1.LT.1.001) GO TO 22
   CK=1.000-CK1
   GO TO 23
22 CK1=CK1/W
   CK=1.000-CK1
   W1=0.000
   W=1.000
23 CONTINUE
   P(I,J)=(W1*P(I,J))+W*(S13*(PB1+P33)+S24*(P22+P44)-F(I,J)/2)
1   /(C13+C24))/CK
   GO TO 477
91 CONTINUE
   IF(J.EQ.1) GO TO 910
   CK1=((W*S1K/S3)+W*S24/S4)/(C13+C24)
   IF(CK1.GT.0.999000.AND.CK1.LT.1.001) GO TO 24
   CK=1.000-CK1
   GO TO 25
24 CK1=CK1/W
   CK=1.000-CK1
   W1=0.000
   W=1.000
25 CONTINUE
   P(I,J)=(W1*P(I,J))+W*(S13*P11+S1K*V1*DX+S24*P22-F(I,J)/2)
1   /(C13+C24))/CK
   GO TO 477
910 CK1=W*S1/(S3*(C13+C24))
   IF(CK1.GT.0.999000.AND.CK1.LT.1.001) GO TO 26
   CK=1.000-CK1
   GO TO 27
26 CK1=CK1/W
   CK=1.000-CK1
   W1=0.000
   W=1.000
27 CONTINUE
   P(I,J)=(W1*P(I,J))+W*(S13*P11+S1K*V1*DX+2*S24*P22-F(I,J)/2)
1   /(C13+C24))/CK
   GO TO 477
92 CONTINUE
   IF(J.GT.V3) GO TO 921
   CK1=((W*S1K/S3)+W*S24/S2)/(C13+C24)
   IF(CK1.GT.0.999000.AND.CK1.LT.1.001) GO TO 28

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```

      CK=1.000-CK1
      GO TO 29
28  CK1=CK1/*
      CK=1.000-CK1
      *1=C.000
      W=1.000
29  CONTINUE
      P(I,J)=(*1*P(I,J)+***(S13*P11+S14*V1*DX+S24*P44-F(I,J)/2)
1    / (C13+C24))/CK
      GO TO 477
921 CONTINUE
      IF(1SYM.EQ.1) GO TO 922
      IF(J.GT.JJC) GO TO 922
      XC1=RC-(1-M1)*DX
      YYC1=DABS(RC*RC-XC1*XC1)
      YC1=DSQRT(YYC1)
      YC2=(RC+B)-(J-1)*DY
      XXC=DABS(RC*RC-YC2*YC2)
      XC2=DSQRT(XXC)
      PB2=XC1*P(I-1,J)/(B1*YC1)
      PB3=YC2*B1*P(I,J-1)/XC2
      CK1=(W*S24*((1/S2)-XC1/(B1*YC1))+W*S14*((1/S3)-YC2*B1/XC2))/(C13
1    +C24)
      IF(CK1.GT.0.999000.AND.C<1.LT.1.001) GO TO 30
      CK=1.000-CK1
      GO TO 31
30  CK1=CK1/*
      CK=1.000-CK1
      *1=0.000
      W=1.000
31  CONTINUE
      P(I,J)=(*1*P(I,J)+W*(S13*(PB3+P11)+S24*(P44+PB2)-F(I,J)/2)
1    / (C13+C24))/CK
      GO TO 477
922 CONTINUE
      PB3=Y2*B1*P(I,J-1)/X2
      PB2=X1*P(I-1,J)/(B1*Y1)
      CK1=(W*S14*((1/S3)-Y2*B1/X2)+W*S24*((1/S2)-X1/(B1*Y1)))/(C13+C24)
      IF(CK1.GT.0.999000.AND.C<1.LT.1.001) GO TO 32
      CK=1.000-CK1
      GO TO 33
32  CK1=CK1/*
      CK=1.000-CK1
      *1=0.000
      W=1.000
33  CONTINUE
      P(I,J)=(*1*P(I,J)+W*(S13*(PB3+P11)+S24*(P44+PB2)-F(I,J)/2)
1    / (C13+C24))/CK
      GO TO 477
93  CONTINUE
      IF(J.GT.N3) GO TO 930
      CK1=W*S14/(S3*(C13+C24))
      IF(CK1.GT.0.999000.AND.C<1.LT.1.001) GO TO 34

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      CK=1.000-CK1
      GO TO 35
34    CK1=CK1/W
      CK=1.000-CK1
      W1=0.000
      W=1.000
35    CONTINUE
      P(I,J)=(W1*P(I,J)+W*(S13*P11+S1K*V1*DX+S24*(P22+P44)-F(I,J)/2)
1      /(C13+C24))/CK
      GO TO 477
930   CONTINUE
      IF(ISYM.EQ.1) GO TO 932
      IF(J.GT.JJC) GO TO 931
      YC2=(RC+B)-(J-1)*DY
      XXC=DABS(RC*RC-YC2*YC2)
      XC2=DSQRT(XXC)
      PB3=YC2*B1*P(I,J-1)/XC2
      CK1=(W*S1K*((1/S3)-YC2*B1/XC2))/(C13+C24)
      IF(CK1.GT.0.999000.AND.CK1.LT.1.001) GO TO 36
      CK=1.000-CK1
      GO TO 37
36    CK1=CK1/A
      CK=1.000-CK1
      W1=0.000
      W=1.000
37    CONTINUE
      P(I,J)=(W1*P(I,J)+W*(S13*(PB3+P11)+S24*(P22+P44)-F(I,J)/2)
1      /(C13+C24))/CK
      GO TO 477
931   CONTINUE
      IF(J.GT.JC) GO TO 932
      P(I,J)=(W1*P(I,J)+W*B*(P11+B3*(P22+P44)-F(I,J)*DX*DX))/WB12
      GO TO 477
932   CONTINUE
      PB3=Y2*B1*P(I,J-1)/X2
      CK1=(W*S1K*((1/S3)-Y2*B1/X2))/(C13+C24)
      IF(CK1.GT.0.999000.AND.CK1.LT.1.001) GO TO 38
      CK=1.000-CK1
      GO TO 39
38    CK1=CK1/W
      CK=1.000-CK1
      W1=0.000
      W=1.000
39    CONTINUE
      P(I,J)=(W1*P(I,J)+W*(S13*(PB3+P11)+S24*(P22+P44)-F(I,J)/2)
1      /(C13+C24))/CK
      GO TO 477
94    CONTINUE
      IF(J.EQ.1) GO TO 945
      IF(I.GE.IC) GO TO 940
      PB4=X1*P(I+1,J)/(B1*Y1)
      CK1=(W*S24*((1/S4)-X1/(B1*Y1)))/(C13+C24)
      IF(CK1.GT.0.999000.AND.CK1.LT.1.001) GO TO 40

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      CK=1.0D0-CK1
      GO TO 41
40    CK1=CK1/W
      CK=1.0D0-CK1
      W1=0.0D0
      W=1.0D0
41    CONTINUE
      P(I,J)=(W1*P(I,J)+W*(S13*(P33+P11)+S24*(P22+PB4)-F(I,J)/2)
1      /((C13+C24))/CK
      GO TO 477
945  CONTINUE
      P(I,J)=(W1*P(I,J)+WB*(P11+P33+2.0D0*PB*P22-F(I,J)*UX*DX)
      GO TO 477
940  CONTINUE
      P(I,J)=(W1*P(I,J)+WB*(P11+P33+BB*P22-F(I,J)*DX*DX))/D
      GO TO 477
95    CONTINUE
      IF(I.GE.1C) GO TO 950
      PB2=X1*P(I+1,J)/(B1*Y1)
      CK1=(W*S24*((1/S2)-X1/(B1*Y1)))/(C13+C24)
      IF(CK1.GT.0.9990D0.AND.CK1.LT.1.001) GO TO 42
      CK=1.0D0-CK1
      GO TO 43
42    CK1=CK1/W
      CK=1.0D0-CK1
      W1=0.0D0
      W=1.0D0
43    CONTINUE
      P(I,J)=(W1*P(I,J)+W*(S13*(P33+P11)+S24*(P44+PB2)-F(I,J)/2)
1      /((C13+C24))/CK
      GO TO 477
923  CONTINUE
      P(I,J)=0.0D0
      GO TO 477
950  CONTINUE
      IF(I.GT.M1) GO TO 951
      PB2=X1*P(I-1,J)/(B1*Y1)
      CK1=(W*S24*((1/S2)-X1/(B1*Y1)))/(C13+C24)
      IF(CK1.GT.0.9990D0.AND.CK1.LT.1.001) GO TO 44
      CK=1.0D0-CK1
      GO TO 45
44    CK1=CK1/W
      CK=1.0D0-CK1
      W1=0.0D0
      W=1.0D0
45    CONTINUE
      P(I,J)=(W1*P(I,J)+W*(S13*(P33+P11)+S24*(P44+PB2)-F(I,J)/2)
1      /((C13+C24))/CK
      GO TO 477
951  CONTINUE
      IF(1SYM.EQ.1) GO TO 952
      IF(I.GT.11C) GO TO 952
      XC1=RC-(I-M1)*DX

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      YYC1=DABS(RC*RC-XC1*XC1)
      YC1=DSQRT(YYC1)
      PB2=XC1*P(I-1,J)/(B1*YC1)
      CK1=W*S24*((1/S2)-XC1/(b1*YC1))/(C13+C24)
      IF(CK1.GT.0.999000.AND.CK1.LT.1.001) GO TO 46
      CK=1.000-CK1
      GO TO 47
46    CK1=CK1/W
      CK=1.000-CK1
      W=0.000
      W=1.000
47    CONTINUE
      P(I,J)=(W1*P(I,J)+W*(S13*(P11+P33)+S24*(P44+PB2)-F(I,J)/2)
1      /(C13+C24))/CK
      GO TO 477
952   CONTINUE
      CK1=W*S24/(S2*(C13+C24))
      IF(CK1.GT.0.999000.AND.CK1.LT.1.001) GO TO 48
      CK=1.000-CK1
      GO TO 49
48    CK1=CK1/W
      CK=1.000-CK1
      W=0.000
      W=1.000
49    CONTINUE
      P(I,J)=(W1*P(I,J)+W*(S13*(P11+P33)+S24*P44-F(I,J)/2)
1      /(C13+C24))/CK
477   CONTINUE
      EPS=EPS+DABS(P(I,J)-SAVP)**2
4     CONTINUE
5     CONTINUE
      IF(ITER/IP*IP.NE.ITER) GO TO 2222
      WRITE(6,102) EPS,ITER
      DO 900 J=1,M2
900   WRITE(6,101) (P(I,J),I=1,M3)
      WRITE(6,104)
      DO 1000 I=1,M3
1000  WRITE(6,103) I,(PBX(I,J),J=1,2)
      WRITE(6,105)
      DO 1100 J=1,M2
1100  WRITE(6,103) J,(PBY(I,J),I=1,2)
2222  CONTINUE
      IF(EPS.LT.1.000) GO TO 3
      WQ=0.9000*WQ
      WUP=0.9000*WUP
      GO TO 2
3     IF(ITER.GE.ITMAX) GO TO 8
      IF(EPS.GE.EPSMAX) GO TO 15
8     CONTINUE
      WRITE(6,102) EPS,ITER
      WRITE(6,14)
C
      DO 6 I=2,M3

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      CALL INTPL(I)
      CALL BCSI(I)
6     CONTINUE
      DO 7 J=1,M21
      CALL IRL(J)
      CALL BCSJ(J,V1)
7     CONTINUE
      IF(IWR.EQ.1) GO TO 222
      WRITE(6,106)
      DO 9 J=1,M21
9     WRITE(6,101) J,(P(I,J),I=1,M3)
      IF(ISYM.EQ.1) GO TO 333
      WRITE(6,104)
      DO 10 I=2,M3
10    WRITE(6,103) I,(PBX(I,J),J=1,2)
      GO TO 444
333   WRITE(6,107)
      DO 12 I=2,M3
12    WRITE(6,108) I,PBX(I,2)
444   WRITE(6,105)
      DO 11 J=1,M21
11    WRITE(6,103) J,(PBX(I,J),I=1,2)
14    FORMAT(///,'*****
1 *****',//)
101   FORMAT(//,7X,'J  =',I2,/,10(5X,5D15.6/))
102   FORMAT(//,10X,'EP5  =',D12.4/10X,'NO. OF ITERATIONS=',I4)
103   FORMAT(/,10X,I4,5X,2(5X,D15.5))
104   FORMAT(//,15X,'I    ',5X,'PBX1',15X,'PBX2')
105   FORMAT(//,15X,'J    ',5X,'PBX1',15X,'PBX2')
106   FORMAT(//,20X,'VALUES OF POTENTIAL VELOCITY P(I,J) FOR INCOMPRESS
      IBLE FLOW',/)
107   FORMAT(//,20X,'I    ',5X,'PBX2',/)
108   FORMAT(/,15X,I4,10X,D15.6)
222   CONTINUE
      RETURN
      END

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      SUBROUTINE ABDLAH
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /ONE/ V1
      COMMON /TJ/ ILJ,IWR,ISYM,IPAP,ICD,IP,ICUM
      COMMON /FORM/ M1,M2,IC,JC,IIC,JJC,M3,N3
      COMMON /MSH/ S1,S2,S3,S4,P1,P2,P3,P4,JL,JU,IL,IR
      COMMON /VEES/ U(50,30),V(50,30),UBX(50,2),VBX(50,2),
1     UBY(2,30),VBY(2,30),U1(50,30),V1(50,30),UBX1(50,2),
1     VBX1(50,2),UBY1(2,30),VBY1(2,30),VV(50,30),ANGLE(50,30)
      COMMON /CAL/ M21,IC1,JC1,M11,N31,IC2
      COMMON /SD/ VVBX(50,2),VVBY(2,30),ANGL1(50,2),ANGL2(2,30)
C
CC CALCULATE THE VELOCITY VECTOR V IN THE SCROLL CROSS SECTION BY
CC USING THE TWO COMPONENTS U,V IN THE X&Y DIRECTIONS
C
      IF(IWR.EQ.1) GO TO 5
      WRITE(6,14)
      WRITE(6,149)
      WRITE(6,150)
5     CONTINUE
      DO 2 I=2,M3
      CALL INTPL(I)
      DO 2 J=JL,JU
      U2=DABS(U(I,J))
      V2=DABS(V(I,J))
      VV(I,J)=DSQRT(U2*U2+V2*V2)
      IF(U(I,J).GT.0.000.AND.V(I,J).LT.0.000) GO TO 82
      IF(U(I,J).LT.0.000.AND.V(I,J).GT.0.000) GO TO 83
      IF(U(I,J).LT.0.000.AND.V(I,J).LT.0.000) GO TO 84
      IF(U(I,J).EQ.0.000.AND.V(I,J).GT.0.000) GO TO 85
      IF(U(I,J).EQ.0.000.AND.V(I,J).LT.0.000) GO TO 86
      IF(U(I,J).GT.0.000.AND.V(I,J).EQ.0.000) GO TO 87
      IF(U(I,J).LT.0.000.AND.V(I,J).EQ.0.000) GO TO 88
      IF(U(I,J).EQ.0.000.AND.V(I,J).EQ.0.000) GO TO 87
      ANGLE(I,J)=(DATAN(V2/U2))*57.296000
      GO TO 1
82     ANGLE(I,J)=(6.283000-(DATAN(V2/U2)))*57.296000
      GO TO 1
83     ANGLE(I,J)=(3.142000-(DATAN(V2/U2)))*57.296000
      GO TO 1
84     ANGLE(I,J)=(3.142000+(DATAN(V2/U2)))*57.296000
      GO TO 1
85     ANGLE(I,J)=90.000
      GO TO 1
86     ANGLE(I,J)=270.000
      GO TO 1
87     ANGLE(I,J)=0.000
      GO TO 1
88     ANGLE(I,J)=180.000
1     CONTINUE
      IF(IWR.EQ.1) GO TO 2
      WRITE(6,100) I,J,VV(I,J), ANGLE(I,J)
2     CONTINUE

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WRITE(6,200)
DO 3 I=2,M3
DO 3 J=1,2
J2=DABS(JBX(I,J))
V2=DABS(VBX(I,J))
VVCX(I,J)=DSQRT(U2*U2+V2*V2)
IF(UBX(I,J).GT.0.000.AND.VBX(I,J).LT.0.000) GO TO 72
IF(JBX(I,J).LT.0.000.AND.VBX(I,J).GT.0.000) GO TO 73
IF(UBX(I,J).LT.0.000.AND.VBX(I,J).LT.0.000) GO TO 74
IF(UBX(I,J).EQ.0.000.AND.VBX(I,J).GT.0.000) GO TO 75
IF(UBX(I,J).EQ.0.000.AND.VBX(I,J).LT.0.000) GO TO 76
IF(UBX(I,J).GT.0.000.AND.VBX(I,J).EQ.0.000) GO TO 77
IF(UBX(I,J).EQ.0.000.AND.VBX(I,J).EQ.0.000) GO TO 77
ANGL1(I,J)=(DATAN(V2/U2))*57.296000
IF(UBX(I,J).LT.0.000.AND.VBX(I,J).EQ.0.000) GO TO 76
GO TO 10
72 ANGL1(I,J)=(6.283000-(DATAN(V2/U2)))*57.296000
GO TO 10
73 ANGL1(I,J)=(3.142000-(DATAN(V2/U2)))*57.296000
GO TO 10
74 ANGL1(I,J)=(3.142000+(DATAN(V2/U2)))*57.296000
GO TO 10
75 ANGL1(I,J)=90.000
GO TO 10
76 ANGL1(I,J)=270.000
GO TO 10
77 ANGL1(I,J)=0.000
GO TO 10
78 ANGL1(I,J)=180.000
10 CONTINUE
IF(IWR.EQ.1) GO TO 3
WRITE(6,100) I,J,VVCX(I,J),ANGL1(I,J)
3 CONTINUE
WRITE(6,300)
DO 4 J=2,M2
DO 4 I=1,2
J2=DABS(UBY(I,J))
V2=DABS(VBY(I,J))
VVBX(I,J)=DSQRT(U2*J2+V2*V2)
IF(UBY(I,J).GT.0.000.AND.VBY(I,J).LT.0.000) GO TO 62
IF(UBY(I,J).LT.0.000.AND.VBY(I,J).GT.0.000) GO TO 63
IF(UBY(I,J).LT.0.000.AND.VBY(I,J).LT.0.000) GO TO 64
IF(UBY(I,J).EQ.0.000.AND.VBY(I,J).GT.0.000) GO TO 65
IF(UBY(I,J).EQ.0.000.AND.VBY(I,J).LT.0.000) GO TO 65
IF(UBY(I,J).GT.0.000.AND.VBY(I,J).EQ.0.000) GO TO 67
IF(UBY(I,J).LT.0.000.AND.VBY(I,J).EQ.0.000) GO TO 68
IF(UBY(I,J).EQ.0.000.AND.VBY(I,J).EQ.0.000) GO TO 67
ANGL2(I,J)=(DATAN(V2/U2))*57.296000
GO TO 20
62 ANGL2(I,J)=(6.283000-(DATAN(V2/U2)))*57.296000
GO TO 20
63 ANGL2(I,J)=(3.142000-(DATAN(V2/U2)))*57.296000
GO TO 20

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64 ANGL2(I,J)=(3.142900+(DATAN(V2/U2)))*57.296000
   GO TO 20
65 ANGL2(I,J)=90.000
   GO TO 20
66 ANGL2(I,J)=270.000
   GO TO 20
67 ANGL2(I,J)=0.000
   GO TO 20
68 ANGL2(I,J)=180.000
20 CONTINUE
   IF(IWR.EQ.1) GO TO 4
   WRITE(6,100) I,J,VVBY(I,J),ANGL2(I,J)
4   CONTINUE
14  FORMAT(111)
100 FORMAT(20X,I5,SX,I5,SX,E20.9,SX,F8.4)
149 FORMAT(/,10X,'ABSOLUTE VELOCITY & ITS DIR. WITH THE X CJO. ',//)
150 FORMAT(/,20X,'I      ',5X,'J      ',5X,'VV      ',20X,'THETA',/)
200 FORMAT(/,20X,'I      ',5X,'J      ',5X,'VV8X   ',20X,'THETA',/)
300 FORMAT(/,20X,'I      ',5X,'J      ',5X,'VVBY   ',20X,'THETA',/)
   RETURN
   END
```

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      SUBROUTINE SHABAN
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /ONE/ V1
      COMMON /TWO/ ILO,IWR,ISYM,IPAP,ICOD,IP,ICOM
      COMMON /FOUR/ RI,RF,IFREV
      COMMON /DIMS/ R,RC,H,B,DX,DY,B1,BB
      COMMON /FORM/ M1,M2,IC,JC,IIC,JJC,M3,N3
      COMMON /MESH/ S1,S2,S3,S4,P1,P2,P3,P4,JL,JU,IL,IR
      COMMON /PHI/ P(50,30),PBY(2,30),PBX(50,2),PP(50,30),PBY1(2,30),
1    PBX1(50,2),F(50,30)
      COMMON /VEES/ U(50,30),V(50,30),UBX(50,2),VBX(50,2),
1    UBY(2,30),VBY(2,30),U1(50,30),V1(50,30),UBX1(50,2)
1    ,VBX1(50,2),UBY1(2,30),VBY1(2,30),VV(50,30),ANGLE(50,30)
      COMMON /CAL/ M21,IC1,JC1,M11,N31,IC2
      COMMON /SH/ RG,GAMA,TD,WV,VE
      COMMON /RQ/ RQA(50,30),RQB(50,2),RQBY(2,30)
      COMMON /GD/ VVEX(50,2),VVBY(2,30),ANGL1(50,2),ANGL2(2,30)
C
CC CALCULATE POISSONS SOURCE DIS. F(I,J)
C
      DO 400 I=1,M3
      IF(IFG.EQ.1) GO TO 101
      DO 400 J=1,M2
400  F(I,J)=0.0D0
      IF(ISYM.EQ.1) IIC=M1
      IF(ISYM.EQ.1.AND.IPAP.EQ.1) GO TO 777
      AA=0.0D0
      DO 555 I=2,IC1
      CALL INTPL(I)
555  AA=AA+(JU-JL)*DY*DX
      DO 556 I=IC2,M11
      CALL INTPL(I)
556  AA=AA+(JU-JL)*DY*DX
      DO 666 I=M1,M3
      CALL INTPL(I)
666  AA=AA+(JU-JL)*DY*DX
      A1=(M3-IIC)*(N3-2)*DX*DY
      IF(ISYM.EQ.1) A1=(M3-IIC)*(N3-1)*DX*DY
      RH=B/(AA-A1)
      IF(IFREV.EQ.1) GO TO 3336
      GO TO 1
3336 CONTINUE
      R11=R1+H+R
      DO 401 I=2,M1
      R22=R1+H+(M1-I)*DX
      CALL INTPL(I)
      DO 401 J=JL,JU
401  F(I,J)=R11*RH/R22
      GO TO 3337
777  CONTINUE
      DO 11 I=2,M11
      CALL INTPL(I)
      DO 12 J=JL,JU

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      X=(I-IC)*DX
      Y=(J-JC)*DY
      F(I,J)=5.3909000*3*(1.000-(X*X+Y*Y)/(K*R))
12  CONTINUE
11  CONTINUE
3337 IF(IC00.EQ.0) GO TO 7
1   IF(IC00.EQ.0) GO TO 17
      CALL HOSNY
      DO 2 I=2,M3
      CALL INTPL(I)
      DO 2 J=JL,JU
2   P(I,J)=ROA(I,J)
      DO 3 I=2,M3
      PBX(I,1)=ROBX(I,1)
3   PBX(I,2)=ROBX(I,2)
      DO 4 J=1,M21
      PBY(1,J)=ROBY(1,J)
4   PBY(2,J)=ROBY(2,J)
      ILO=1
      CALL HVVE_
      IF(IPAP.EQ.1) RH=0.000
      IF(IFREVO.EQ.1) RH=0.000
      IF(ISYM.EQ.1) IIC=M1-1
      DO 5 I=2,M3
      IF(I.GT.IIC) RH=0.000
      CALL INTPL(I)
      DO 5 J=JL,JU
5   F(I,J)=F(I,J)*(ROBY(2,2)/ROA(I,J))+RH*(ROBY(2,2)/ROA(I,J))-
1   (U1(I,J)*U(I,J)+V0(I,J)*V(I,J))/ROA(I,J)
      GO TO 7
17  DO 6 I=2,M3
      IF(I.GT.IIC) RH=0.000
      CALL INTPL(I)
      DO 8 J=JL,JU
8   F(I,J)=RH
7   AE=0.000
      DO 444 I=2,IC1
      CALL INTPL(I)
      J1=JL
      J2=JU-1
      DO 444 J=J1,J2
444 AE=AE+((F(I,J)+F(I+1,J)+F(I,J+1)+F(I+1,J+1))/4)*DX*DY
      DO 4446 I=IC2,M11
      CALL INTPL(I)
      J1=JL
      J2=JU-1
      DO 4446 J=J1,J2
4446 AE=AE+((F(I,J)+F(I-1,J)+F(I,J+1)+F(I-1,J+1))/4)*DX*DY
      DO 333 I=M1,M3
      CALL INTPL(I)
      J1=JL
      J2=JU-1
      DO 333 J=J1,J2

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353 AE=AE+((F(I,J)+F(I-1,J)+F(I,J+1)+F(I-1,J+1))/4)*DX*DY
AN=(B-N31*DY)*V1*ROBY(2,2)
DO 29 J=1,M31
29 AN=AN+V1*DY*ROBY(2,2)
IF(I SYM.EQ.1.AND.IPAP.EQ.1) AA=1.57143000*R*K
DO 30 I=2,M3
CALL INTPL(I)
DO 30 J=JL,JU
30 F(I,J)=F(I,J)-(AE-AN)/AA
101 CONTINUE
IF(IWR.EQ.1) GO TO 300
WRITE(6,200)
DO 9 I=2,M3
9 WRITE(6,100) I,(F(I,J),J=1,M21)
WRITE(6,14)
14 FORMAT(//,'*****')
1 *****',//]
100 FORMAT(//,7X,'I =',I10,/,4(8F10.5))
200 FORMAT(/,10X,'POISSONS SOURCE DIS. AT EACH GRID POINT',//)
300 CONTINUE
RETURN
END

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      SUBROUTINE HQSVY
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /TWO/ ILO,IWR,ISYM,IPAP,ICD,IP,ICOM
      COMMON /FOUR/ R1,RF,IFREVJ
      COMMON /DIMS/ R,RC,H,B,DX,DY,B1,BB
      COMMON /FORM/ M1,M2,IC,JC,IIC,JJC,M3,N3
      COMMON /MSH/ S1,S2,S3,S4,P1,P2,P3,P4,JL,JU,IL,IR
      COMMON /VEES/ U(50,30),V(50,30),UBX(50,2),VBX(50,2),
1  UBY(2,30),VBY(2,30),U1(50,30),V1(50,30),UBX1(50,2),
1  ,VBX1(50,2),JBY1(2,30),VBY1(2,30),VV(50,30),ANGLE(50,30)
      COMMON /CAL/ M21,IC1,JC1,M11,N31,IC2
      COMMON /SH/ RG,GAMA,TO,WV,VE
      COMMON /RO/ ROA(50,30),ROBX(50,2),RJBY(2,30)
      COMMON /GO/ VVEX(50,2),VVBY(2,30),ANGL1(50,2),ANGL2(2,30)

C
CC CALCULATE DENSITY ROA(I,J) AT EACH GRID POIN
C
      CP=RG*GAMA/(GAMA-1.0D0)
      POWER=1.0D0/(GAMA-1.0D0)
83  DK=VE*VE/(2.0D0*CP*TO)
      IF(IPAP.EQ.1) GO TO 4
      DO 1 I=2,M3
      CALL INTPL(I)
      DO 1 J=JL,JU
      VEL=VV(I,J)*VV(I,J)+WV*WV
      T=1.0D0-DK*VEL
      IF(T.LE.0.000010D0) GO TO 80
      ROA(I,J)=T**POWER
1  CONTINUE
      GO TO 8
4  CONTINUE
      DO 5 I=2,M3
      CALL INTPL(I)
      DO 5 J=JL,JU
      X=(I-IC)*DX
      Y=(J-JC)*DY
      WV=5.090D0*B*(1.0D0/RF)*(1.0D0-(X*X+Y*Y)/(R*R))
      VEL=VV(I,J)*VV(I,J)+WV*WV
      T=1.0D0-DK*VEL
      IF(T.LE.0.000010D0) GO TO 80
      ROA(I,J)=T**POWER
5  CONTINUE
8  DO 2 I=2,M3
      DO 2 J=1,2
      VEL=VVBX(I,J)*VVBX(I,J)
      T=1.0D0-DK*VEL
      IF(T.LE.0.000010D0) GO TO 80
2  ROBX(I,J)=T**POWER
      DO 3 J=2,M21
      DO 3 I=1,2
      VEL=VVBY(I,J)*VVBY(I,J)
      T=1.0D0-DK*VEL
      IF(T.LE.0.000010D0) GO TO 80

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```
3  ROBY(I,J)=T**POWER
   GO TO 90
80  CONTINUE
   WRITE(6,32) I,J,T,VEL,DK
82  FORMAT(5X,2I10,3F12.7)
   VE=.90D0*VE
   WRITE(6,34) VE
84  FORMAT(20X,'VE=',F12.7, '//')
   GO TO 83
90  RETURN
   END
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SUBROUTINE INTPL(I)

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C
CC SUBROUTINE INTPL(I) FOR DETERMINING BOUNDARY POINTS FOR A GIVEN
CC COLUMN I,(I,JL(I)) IS THE LOWER MOST INTERIOR POINT AND
CC (I,JU(I)) IS THE UPPER MOST INTERIOR POINT
C
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /TWO/ ILU,IWK,ISYM,IPAP,ICOD,IP,ICGM
      COMMON /DIMS/ R,RC,I,B,DX,DY,S1,BB
      COMMON /FORM/ M1,M2,IC,JC,IIC,JJC,M3,N3
      COMMON /PSH/ S1,S2,S3,S4,P1,P2,P3,P4,JL,JU,IL,IK

C
      IF(I.GT.IC) GO TO 10
      X=(I-1)*DX-R
      YY2=DABS(R*R-X*X)
      YY=DSQRT(YY2)
      IF(ISYM.EQ.1) GO TO 9
      Y1=R-YY
      Y2=R+YY
      JL=(Y1/DY+0.0100000)+2
      JU=(Y2/DY-0.0100000)+1
      GO TO 40
9     JL=1
      JU=(YY/DY-0.0100000)+1
      GO TO 40
10    CONTINUE
      IF(I.EQ.M1) GO TO 19
      IF(I.GT.M1) GO TO 20
      X=(I-1)*DX-R
      YY2=DABS(R*R-X*X)
      YY=DSQRT(YY2)
      IF(ISYM.EQ.1) GO TO 18
      JL=2
      Y2=R+YY
      JU=(Y2/DY-0.0100000)+1
      GO TO 40
18    JL=1
      JU=(YY/DY-0.0100000)+1
      IF(YY.LT.B) JU=N3
      GO TO 40
20    CONTINUE
      IF(ISYM.EQ.1) GO TO 30
      JL=2
      IF(I.GT.IIC) GO TO 30
      X=RC-(I-M1)*DX
      YY2=DABS(RC*RC-X*X)
      YY=DSQRT(YY2)
      Y1=(RC+B)-YY
      JU=(Y1/DY-0.0100000)+1
      GO TO 40
19    CONTINUE
      IF(ISYM.EQ.1) GO TO 30
      JL=2

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	JU=JJC	31M
	GO TO 40	32
30	CONTINUE	33
	JL=2	34
	IF (ISYM.EQ.1) JL=1	
	JU=(B/DY-0.0010000)+1	
40	CONTINUE	
	RETURN	
	END	

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      SUBROUTINE MESH(I,J)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /T#0/ ILO, IHR, ISYM, IPAP, ICOD, IP, ICOM
      COMMON /DIMS/ R, RC, H, B, DX, DY, B1, B2
      COMMON /FORM/ M1, M2, IC, JC, IIC, JJC, M3, N3
      COMMON /MSH/ S1, S2, S3, S4, P1, P2, P3, P4, JL, JU, IL, IR
      COMMON /P#1/ P(50,30), PBX(2,30), PBX1(50,2), PP(50,30), PBY1(2,30),
      1 PBX1(50,2), F(50,30)
C
CC DETERMINE THE STANDARD FIVE POINTS LAPLACE DIFF. OPERATOR AND
CC THEIR POSITIONS S1, S2, S3, S4 w.r.t. POINT O(X,Y)
C
      IF(J.EQ.JL.AND.J.EQ.JU) GO TO 101
      IF(J.EQ.JL) GO TO 50
      IF(J.EQ.JJ) GO TO 60
      S2=1.0D0
      P2=P(I,J+1)
      S4=1.0D0
      P4=P(I,J-1)
      GO TO 70
50  CONTINUE
      IF(ISYM.EQ.1) GO TO 51
      IF(I.GT.IC) GO TO 51
      S2=1.0D0
      P2=P(I,J+1)
      X=R-(I-1)*DX
      YY2=DABS(R*R-X*X)
      YY=DSQRT(YY2)
      Y1=YY-(JC-J)*DY
      S4=Y1/DY
      IF(S4.GT.1.0D0) S4=1.0D0
      P4=PBX(I,1)
      GO TO 70
51  CONTINUE
      S2=1.0D0
      P2=P(I,J+1)
      S4=1.0D0
      P4=PBX(I,1)
      GO TO 70
60  CONTINUE
      IF(I.EQ.M1) GO TO 62
      IF(I.GT.M1) GO TO 65
      X=(IC-I)*DX
      YY2=DABS(R*R-X*X)
      YY=DSQRT(YY2)
      Y1=YY-(J-JC)*DY
      S2=Y1/DY
      IF(YY.LT.B) S2=(B-(J-1)*DY)/DY
      IF(S2.GT.1.0D0) S2=1.0D0
      P2=PBX(I,2)
      S4=1.0D0
      P4=P(I,J-1)
      GO TO 70

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0035

62	CONTINUE	0048
	IF(1SYM.EQ.1) GO TO 64	
	S2=1.3D0	
	P2=PBX(1,2)	0050
	S4=1.0D0	
	P4=P(1,J-1)	0052
	GO TO 70	0053
65	CONTINUE	0054
	IF(1SYM.EQ.1) GO TO 64	
	IF(1.GT.1IC) GO TO 64	0055
	XC=RC-(1-M1)*DX	0056
	YY2=DABS(RC*RC-XC*XC)	
	YY=DSQRT(YY2)	
	YC=B+RC-YY-(J-1)*DY	0059
	S2=YC/DY	0060
	IF(S2.GT.1.0D0) S2=1.0D0	
	P2=PBX(1,2)	0061
	S4=1.0D0	
	P4=P(1,J-1)	0063
	GO TO 70	0064
64	CONTINUE	0065
	Y2=B-(J-1)*DY	0066
	S2=Y2/DY	0067
	IF(S2.GT.1.0D0) S2=1.0D0	
	P2=PBX(1,2)	0068
	S4=1.0D0	
	P4=P(1,J-1)	0070
	GO TO 70	
101	CONTINUE	
	Y=B-(J-1)*DY	
	S2=Y/DY	
	IF(S2.GT.1.0D0) S2=1.0D0	
	P2=PBX(1,2)	
	S4=1.0D0	
	P4=PBX(1,1)	
70	CONTINUE	0071
	IF(1.EQ.1L) GO TO 80	0073
	IF(1.EQ.1R) GO TO 90	0074
	S1=1.0D0	
	P1=P(1-1,J)	0076
	S3=1.0D0	
	P3=P(1+1,J)	0078
	GO TO 100	0079
80	CONTINUE	0080
	Y=(JC-J)*DY	
	XX2=DABS(R*R-Y*Y)	
	XX=DSQRT(XX2)	
	X1=XX-(IC-1)*DX	0085
	S1=X1/DX	0086
	IF(S1.GT.1.0D0) S1=1.0D0	
	P1=PBX(1,J)	0087
	S3=1.0D0	
	P3=P(1+1,J)	

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	GO TO 100	0090
50	CONTINUE	00101
	IF(J.GT.N3) GO TO 91	00102
	S1=1.000	
	P1=P(I-1,J)	
	XX=H-(M3-M1)*DX	00104
	S3=XX/DX	00105
	IF(S3.GT.1.000) S3=1.000	00106
	P3=PBX(2,J)	
	GO TO 100	00107
91	CONTINUE	00108
	IF(1SYM.EQ.1) GO TO 93	00109
	IF(J.GT.JJC) GO TO 92	
	S1=1.000	00110
	P1=P(I-1,J)	
	YC=B+RC-(J-1)*DY	00112
	XXC=DABS(RC*RC-YC*YC)	00113
	XC=DSQRT(XXC)	
	X1=RC-XC-(I-M1)*DX	
	S3=X1/DX	00116
	IF(S3.GT.1.000) S3=1.000	00117
	P3=PBX(2,J)	
	GO TO 100	00118
92	CONTINUE	00119
	IF(J.GT.JC) GO TO 93	00120
	S1=1.000	00121
	P1=P(I-1,J)	
	S3=1.000	00123
	P3=PBX(2,J)	
	GO TO 100	00125
93	CONTINUE	00126
	S1=1.000	00127
	P1=P(I-1,J)	
	Y=(J-JC)*DY	00129
	XX2=DABS(R*R-Y*Y)	00130
	XX=DSQRT(XX2)	
	X1=XX-(I-IC)*DX	
	S3=X1/DX	00133
	IF(S3.GT.1.000) S3=1.000	00134
	P3=PBX(2,J)	
100	CONTINUE	00135
	RETURN	00136
	END	00139

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      SUBROUTINE IRL(J)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /TWO/ IL0,IWR,ISYM,IPAP,ICD0,IP,ICOM
      COMMON /DIMS/ R,RC,H,B,DX,DY,B1,B3
      COMMON /FORM/ M1,M2,IC,JC,IIC,JJC,M3,N3
      COMMON /MSH/ S1,S2,S3,S4,P1,P2,P3,P4,JL,JU,IL,IR
C
CC SUBROUTINE IRL(J) FOR DETERMINING BOUNDARY POINTS FOR A GIVEN
CC ROW J,(J,IL(J)) IS THE FIRST INTERIOR POINT &(J,IR(J)) IS THE MAXIMUM
CC INTERIOR POINT
C
      IF(J.GT.N3) GO TO 1000
      Y=(JC-J)*DY
      XX2=DABS(R*R-Y*Y)
      XX=DSQRT(XX2)
      X1=R-XX
      IL=(X1/DX+0.0100000)+2
      IR=M3
      GO TO 4000
1000 CONTINUE
      IF(ISYM.EQ.1) GO TO 3000
      IF(J.GT.JJC) GO TO 2000
      Y=R-(J-1)*DY
      XX2=DABS(R*R-Y*Y)
      XX=DSQRT(XX2)
      X1=R-XX
      IL=(X1/DX+0.0100000)+2
      YC=B+RC-(J-1)*DY
      XXC=DABS(RC*RC-YC*YC)
      XC=DSQRT(XXC)
      X1=RC-XC
      IP=(X1/DX-0.0100000)+M1
      GO TO 4000
2000 CONTINUE
      IF(J.GT.JC) GO TO 3000
      Y=(J-1)*DY-R
      XX2=DABS(R*R-Y*Y)
      XX=DSQRT(XX2)
      X1=R-XX
      IL=(X1/DX+0.0100000)+2
      IR=M1-1
      GO TO 4000
3000 CONTINUE
      Y=(J-JC)*DY
      XX2=DABS(R*R-Y*Y)
      XX=DSQRT(XX2)
      X1=R-XX
      IL=(X1/DX+0.0100000)+2
      IR=(XX/DX-0.0100000)+IC
4000 CONTINUE
      RETURN
      END

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      SUBROUTINE ECSI(I)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /TND/ ILJ,IWR,ISYM,IPAP,ICD,IP,ICOM
      COMMON /DIMS/ R,RC,H,B,DX,DY,B1,BB
      COMMON /FORM/ M1,M2,IC,JC,IIC,JJC,M3,N3
      COMMON /MSH/ S1,S2,S3,S4,P1,P2,P3,P4,JL,JU,IL,IK
      COMMON /PHI/ P(50,30),PBX(2,30),PBX(50,2),PP(50,30),PBY(2,30),
1    PBX1(50,2),F(50,30)
      COMMON /INPC/ PL,PU,PT,PR
C
CC CALCULATE POTENTIAL FUNCTION ALONG THE B. FOR EACH I (PBX1,PBX2)
C
      IF(I .GE. IC) GO TO 180
      J=JL
      CALL IRL(J)
      CALL MESH(I,J)
      X=(IC-1)*DX
      YY=DABS(R*R-X*X)
      Y=DSORT(YY)
      IF(ISYM.EQ.1) GO TO 100
      SS=S4*DY*X+DX*Y
      PL=(1+S4)*P(I+1,J)-S4*P(I+1,J+1)
      PBX(I,1)=(S4*Y*X*P_+DX*Y*P(I,J))/SS
      GO TO 101
100  PBX(I,1)=P(I,J)
      PL=PBX(I,1)
101  J=JU
      CALL IRL(J)
      CALL MESH(I,J)
      SS=S2*DY*X+DX*Y
      PU=(1+S2)*P(I+1,J)-S2*P(I+1,J-1)
      PBX(I,2)=(DX*Y*P(I,J)+DY*S2*X*PU)/SS
      GO TO 900
180  CONTINUE
      IF(I .GT. IC) GO TO 190
      J=JL
      PBX(I,1)=P(I,J)
      PL=PBX(I,1)
      J=JU
      PBX(I,2)=P(I,J)
      PU=PBX(I,2)
      GO TO 900
190  CONTINUE
      IF(I .GE. M1) GO TO 210
      J=JL
      PBX(I,1)=P(I,J)
      PL=PBX(I,1)
      J=JU
      IF(J.LE.N3) GO TO 216
      CALL IRL(J)
      CALL MESH(I,J)
      X=(I-IC)*DX
      YY=DABS(R*R-X*X)

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      Y=DSQRT(YY)
      SS=DY*S2*X+DX*Y
      PU=(1+S2)*P(I-1,J)-S2*P(I-1,J-1)
      PBX(I,2)=(DX*Y*P(I,J)+S2*DY*X*PU)/SS
      GO TO 900
210  PBX(I,2)=P(I,J)
      PU=PBX(I,2)
      GO TO 900
210  CONTINUE
      IF(ISYM.EQ.1) GO TO 214
      IF(I.GT.M1) GO TO 212
      J=JL
      PBX(I,1)=P(I,J)
      PL=PBX(I,1)
      J=JU
      PBX(I,2)=P(I-1,J+1)
      PU=PBX(I,2)
      GO TO 900
212  CONTINUE
      IF(I.GT.IIC) GO TO 214
      J=JL
      PBX(I,1)=P(I,J)
      PL=PBX(I,1)
      J=JU
      CALL IRL(J)
      CALL MESH(I,J)
      X=RC-(I-M1)*DX
      YY=DABS(RC*RC-X*X)
      Y=DSQRT(YY)
      SS=DY*S2*X+DX*Y
      PU=(1+S2)*P(I-1,J)-S2*P(I-1,J-1)
      PBX(I,2)=(DY*S2*X*PU+DX*Y*P(I,J))/SS
      GO TO 900
214  CONTINUE
      J=JL
      PBX(I,1)=P(I,J)
      PL=PBX(I,1)
      J=JU
      PBX(I,2)=P(I,J)
      PU=PBX(I,2)
900  CONTINUE
      RETURN
      END

```

```

      SUBROUTINE BCSJ(J,V1)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /TWO/ ILJ,IWR,ISYM,IPAP,ICOD,IP,ICDM
      COMMON /JIMS/ R,RC,H,B,DX,DY,B1,B2
      COMMON /URM/ M1,M2,IC,JC,IIC,JJC,M3,N3
      COMMON /MSH/ S1,S2,S3,S4,P1,P2,P3,P4,JL,JU,IL,IR
      COMMON /PHI/ P(50,30),PBY(2,30),PBX(50,2),PP(50,30),PBY1(2,30),
1     PBX1(50,2),F(50,30)
      COMMON /INPD/ PL,PU,PT,PR
C
CC CALCULATE POTENTIAL FUNCTION ALONG THE B. FOR EACH J (PBY1,PBY2)
C
      IF(J .GE. JC) GO TO 200
      I=IL
      CALL INTPL(I)
      CALL MESH(I,J)
      Y=(JC-J)*DY
      XX=DABS(R*R-Y*Y)
      X=DSQRT(XX)
      SS=DY*X+DX*S1*Y
      PT=(1+S1)*P(I,J+1)-S1*P(I+1,J+1)
      PBY(1,J)=(DY*X*P(I,J)+DX*S1*Y*PT)/SS
      I=IR
      CALL INTPL(I)
      CALL MESH(I,J)
      IF(J .GT. N3) GO TO 110
      PBY(2,J)=P(I,J)+DX*S3*V1
      PR=PBY(2,J)
      GO TO 900
110 CONTINUE
      IF(J .GT. JJC) GO TO 120
      Y=B+RC-(J-1)*DY
      XX=DABS(RC*RC-Y*Y)
      X=DSQRT(XX)
      SS=DX*S3*Y+DY*X
      PR=(1+S3)*P(I,J-1)-S3*P(I-1,J-1)
      PBY(2,J)=(DY*X*P(I,J)+DX*S3*Y*PR)/SS
      GO TO 900
120 CONTINUE
      PBY(2,J)=P(I,J)
      PR=PBY(2,J)
      GO TO 900
200 CONTINUE
      IF(J .GT. JC) GO TO 210
      I=IL
      PBY(1,J)=P(I,J)
      PT=PBY(1,J)
      I=IR
      CALL INTPL(I)
      CALL MESH(I,J)
      IF(ISYM.EQ.1) GO TO 101
      PBY(2,J)=P(I,J)
      GO TO 102

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101 PBY(2,J)=P(1,J)+DX*S3*V1
102 PR=PBY(2,J)
GO TO 900
210 CONTINUE
I=IL
CALL INTPL(I)
CALL MESH(I,J)
Y=(J-JC)*DY
XX=DABS(R*R-Y*Y)
X=DSQRT(XX)
SS=DX*S1*Y+DY*X
PT=(1+S1)*P(I,J-1)-S1*P(I+1,J-1)
PSY(1,J)=(DX*S1*Y*PT+DY*X*P(I,J))/SS
I=IR
CALL INTPL(I)
CALL MESH(I,J)
IF(ISYM.EQ.0) GO TO 260
IF(J.GT.N3) GO TO 260
PBY(2,J)=P(1,J)+DX*S3*V1
PR=PBY(2,J)
GO TO 900
260 Y=(J-JC)*DY
XX=DABS(R*R-Y*Y)
X=DSQRT(XX)
SS=DX*S3*Y+DY*X
PP=(1+S3)*P(I,J-1)-S3*P(I-1,J-1)
PSY(2,J)=(DY*X*P(1,J)+DX*S3*Y*PR)/SS
900 CONTINUE
RETURN
END

```



```

      SUBROUTINE HVVEL
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /ONE/ V1
      COMMON /T*O/ ILU,IWR,ISYM,IPAP,ICOD,IP,ICOM
      COMMON /DIMS/ R,KC,I,B,DX,DY,B1,BB
      COMMON /FORM/ M1,M2,IC,JC,IIC,JJC,M3,N3
      COMMON /MSH/ S1,S2,S3,S4,P1,P2,P3,P4,JL,JU,IL,IA
      COMMON /PHI/ P(50,30),PBY(2,30),PBX(50,2),PP(50,30),PBY1(2,30),
1    PBX1(50,2),F(50,30)
      COMMON /VEES/U(50,30),V(50,30),UBX(50,2),VBX(50,2),
1    UBY(2,30),VBY(2,30),U1(50,30),V1(50,30),UBX1(50,2),
1    VBX1(50,2),UBY1(2,30),VBY1(2,30),VV(50,30),ANGLE(50,30)
      COMMON /INPD/ PL,PU,PT,PR

```

C

CC CALCULATE VELOCITY COMPONENTS J,V IN THE X&Y DIR. (U=DP/DX ,V=DP/DY)

C

```

      IF(IWR.EQ.1) GO TO 25
      WRITE(6,14)
      WRITE(6,400)
      WRITE(6,107)
25  CONTINUE
      DO 10 I=2,M3
      CALL INTP_(I)
      DO 20 J=JL,JU
      CALL IRL(J)
      CALL MESH(I,J)
      C13=S1/(S3*(S3+S1))
      C31=S3/(S1*(S3+S1))
      C1=(S1-S3)/(S1*S3)
      C24=S2/(S4*(S2+S4))
      C42=S4/(S2*(S2+S4))
      C2=(S4-S2)/(S2*S4)
      U(I,J)=(P3*C13-P1*C31-P(I,J)*C1)/DX
      IF(J.EQ.1) P4=P2
      V(I,J)=(P2*C42-P4*C24-P(I,J)*C2)/DY
      IF(ILO.EQ.1) GO TO 20
      U1(I,J)=U(I,J)
      V1(I,J)=V(I,J)
      IF(IWR.EQ.1) GO TO 20
      *WRITE(6,111) I,J,U(I,J),V(I,J)
20  CONTINUE
10  CONTINUE
      IF(IWR.EQ.1) GO TO 30
      IF(ISYM.EQ.1) GO TO 666
      WRITE(6,108)
      GO TO 30
666 *WRITE(6,109)
30  IF(ISYM.EQ.1) IIC=M1
      DO 50 I=2,M3
      CALL INTPL(I)
      IF(ILEQ.M3) GO TO 100
      J=JL
      CALL IRL(J)

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```

      CALL MESH(I,J)
      CALL BCS1(I)
      IF(I.GE.IC) PL=PBX(I+1,1)
      UBX(I,1)=(PL-PBX(I,1))/DX
      VBX(I,1)=(P(I,J)-PBX(I,1))/(S4*DY)
      J=JU
      CALL IRL(J)
      CALL MESH(I,J)
      CALL BCS1(I)
      IF(I.GE.IIC) PU=PBX(I+1,2)
      JBX(I,2)=(PU-PBX(I,2))/DX
      IF(I.GT.IC) UBX(I,2)=-UBX(I,2)
      IF(I.GE.IIC) UBX(I,2)=-UBX(I,2)
      VBX(I,2)=(PBX(I,2)-P(I,J))/(S2*DY)
      GO TO 900
100  CONTINUE
      J=JL
      UBX(I,1)=(PBX(I,1)-PBX(I-1,1))/DX
      VBX(I,1)=(P(I,J)-PBX(I,1))/DY
      J=JU
      CALL IRL(J)
      CALL MESH(I,J)
      CALL BCS1(I)
      UBX(I,2)=(PBX(I,2)-PBX(I-1,2))/DX
      VBX(I,2)=(PBX(I,2)-P(I,J))/(S2*DY)
900  CONTINUE
      IF(ILO.EQ.1) GO TO 50
      UBX1(I,1)=UBX(I,1)
      VBX1(I,1)=VBX(I,1)
      UBX1(I,2)=UBX(I,2)
      VBX1(I,2)=VBX(I,2)
      IF(IWR.EQ.1) GO TO 50
      IF(ISYM.EQ.1) GO TO 103
      WRITE(6,310) UBX(I,1),VBX(I,1),UBX(I,2),VBX(I,2)
      GO TO 50
103  WRITE(6,210) UBX(I,2),VBX(I,2)
50   CONTINUE
      M21=M2-1
      IF(IWR.EQ.1) GO TO 15
      WRITE(6,777)
15   CONTINUE
      DO 60 J=2,M21
      CALL IRL(J)
      I=IL
      CALL INTPL(I)
      CALL MESH(I,J)
      CALL BCSJ(J,V1)
      UBY(I,J)=(P(I,J)-PBY(I,J))/(S1*DX)
      VBY(I,J)=(PT-PBY(I,J))/DY
      IF(J.GE.JC) VBY(I,J)=-VBY(I,J)
      I=IR
      CALL INTPL(I)
      CALL MESH(I,J)

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      CALL BCSJ(J,V1)
      IF(J.GT.N3) GO TO 180
      UBY(2,J)=(PBY(2,J)-P(I,J))/(S3*DX)
      VBY(2,J)=0.000
      GO TO 2000
180  CONTINUE
      IF(1SYM.EQ.1) GO TO 240
      IF(J.GT.JJC) GO TO 190
      UBY(2,J)=(PBY(2,J)-P(I,J))/(S3*DX)
      VBY(2,J)=(PBY(2,J)-PR)/DY
      GO TO 2000
190  CONTINUE
      IF(J.GE.JC) GO TO 220
      UBY(2,J)=(PBY(2,J)-P(I,J))/DX
      VBY(2,J)=(PBY(2,J+1)-PBY(2,J))/DY
      GO TO 2000
220  CONTINUE
      IF(J.GT.JC) GO TO 240
      UBY(2,J)=(PBY(2,J)-P(I,J))/DX
      VBY(2,J)=(PBY(2,J)-PBY(2,J-1))/DY
      GO TO 2000
240  CONTINUE
      UBY(2,J)=(PBY(2,J)-P(I,J))/(S3*DX)
      VBY(2,J)=(PBY(2,J)-PR)/DY
2000 CONTINUE
      IF(1LJ.EQ.1) GO TO 60
      UBY1(1,J)=UBY(1,J)
      VBY1(1,J)=VBY(1,J)
      UBY1(2,J)=UBY(2,J)
      VBY1(2,J)=VBY(2,J)
      IF(1WR.EQ.1) GO TO 60
      WRITE(6,310) UBY(1,J),VBY(1,J),UBY(2,J),VBY(2,J)
60   CONTINUE
14   FORMAT(1H1)
107  FORMAT(//,10X,'I',5X,'J',5X,'U',20X,'V')
108  FORMAT(//,10X,'UBX1',15X,'VBX1',15X,'UBX2',15X,'VBX2')
111  FORMAT(10X,15,5X,15,10X,15,6,10X,15,6)
210  FORMAT(//,10X,2(5X,015.6))
310  FORMAT(//,10X,4(5X,015.6))
400  FORMAT(10X,'VELOCITY COMP. U&V IN THE X&Y DIR.',//)
777  FORMAT(//,10X,'UBY1',15X,'VBY1',15X,'UBY2',15X,'VBY2')
109  FORMAT(//,15X,'UBX2',15X,'VBX2',/,)
      RETURN
      END

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SUBROUTINE PLTISD(JMAXC,ISYMBL,IUPQDW,SIZE,VISOBR,VAR,X,Y)
IMPLICIT REAL*8 (A-H,O-Z)
COMMON /MSH/ S1,S2,S3,S4,P1,P2,P3,P4,JL,JU,IL,IR
DIMENSION VAR(32,21),X(32,21),Y(32,21)
IC=ISYMBL
ICA=IUPQDW
JMAXO1=JMAXC-1
NNN=1
1115 CONTINUE
1113 JC 1128 J=1,JMAXO1
CALL IRL(J)
DO 1130 INV=IL,IR
IIB=1
I=IR+IL-INV
1103 IF((VAR(I,J).GT.VISOBR).AND.(VAR(I,J+1).GT.VISOBR)) GO TO 1117
IF((VAR(I,J).LT.VISOBR).AND.(VAR(I,J+1).LT.VISOBR)) GO TO 1117
IIB=1
DS= X(I,J+1)- X(I,J)
DSS=DS*(VISOBR-VAR(I,J))/(VAR(I,J+1)-VAR(I,J))
C YYB= ( Y(I,J)+ Y(I,J+1))/2.
DN= Y(I,J+1)- Y(I,J)
DNN=DN*(VISOBR-VAR(I,J))/(VAR(I,J+1)-VAR(I,J))
XXB= ( X(I,J)+DSS)
YYB= ( Y(I,J+1)-(DN-DNN))
WRITE(6,1114) XXB,YYB,I,J,VISOBR,VAR(I,J+1),VAR(I,J),DS,DN
1114 FORMAT(2X,'XXB=',F10.5,2X,'YYB=',F10.6,2X,'I=',I3,2X,'J=',I2,2X,
1 'VISOBR=',F14.6,3X,4(F10.6))
IF(NNN.EQ.1) GO TO 1116
CALL SYMBOL(XXB,YYB,SIZE,IC,0.,-1)
C CALL SYMBOL (-YYB,XXB,SIZE,IC,0.,-1)
CCC CALL SYMBOL(XXB,YYB,SIZE,IC,0.,-ICA)
GO TO 1120
1116 NNN=0
CALL SYMBOL(XXB,YYB,SIZE,IC,0.,-1)
C CALL SYMBOL (-YYB,XXB,SIZE,IC,0.,-1)
GO TO 1120
1117 IIB=2
IF((VAR(I,J).GT.VISOBR).AND.(VAR(I-1,J).GT.VISOBR)) GO TO 1123
IF((VAR(I,J).LT.VISOBR).AND.(VAR(I-1,J).LT.VISOBR)) GO TO 1123
1109 DN=( Y(I,J)- Y(I-1,J))
DNN=DN*(VISOBR-VAR(I-1,J))/(VAR(I,J)-VAR(I-1,J))
YYB= ( Y(I,J)-(DN-DNN))
DS= X(I,J)- X(I-1,J)
DSS=DS*(VISOBR-VAR(I-1,J))/(VAR(I,J)-VAR(I-1,J))
XXB= ( X(I,J)-(DS-DSS))
WRITE(6,1114) XXB,YYB,I,J,VISOBR,VAR(I-1,J),VAR(I,J),DS,DN
IF(NNN.EQ.1) GO TO 1118
ICA=2
IF(IIB.EQ.2) ICA=1
CALL SYMBOL(XXB,YYB,SIZE,IC,0.,-ICA)
C CALL SYMBOL (-YYB,XXB,SIZE,IC,0.,-1)
IF(IIB.EQ.1) GO TO 1127
GO TO 1124

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1118 NNN=0
      CALL SYMBOL (XXB,YYB,SIZE,IC,0.,-1)
C      CALL SYMBOL (-YYB,XXB,SIZE,IC,0.,-1)
      IF (IIB.EQ.1) GO TO 1127
      GO TO 1124
1120 IF ((VAR(I-1,J+1).GT.VISOBR).AND.(VAR(I,J+1).GT.VISOBR)) GO TO
1 1124
      IF ((VAR(I-1,J+1).LT.VISOBR).AND.(VAR(I,J+1).LT.VISOBR)) GO TO
1 1124
1121 DN=(Y(I,J+1)-Y(I-1,J+1))
      DNN=DN*(VISOBR-VAR(I-1,J+1))/(VAR(I,J+1)-VAR(I-1,J+1))
      YYB= (Y(I,J+1)-(DN-DNN))
      DS= X(I,J+1)-X(I-1,J+1)
      DSS=DS*(VISOBR-VAR(I-1,J+1))/(VAR(I,J+1)-VAR(I-1,J+1))
      XXB= (X(I,J+1)-(DS-DSS))
      WRITE(6,1114) XXB,YYB,I,J,VISOBR,VAR(I-1,J+1),VAR(I,J+1),DS,DN
      IF (NNN.EQ.1) GO TO 1122
      CALL SYMBOL (XXB,YYB,SIZE,IC,0.,-2)
C      CALL SYMBOL (-YYB,XXB,SIZE,IC,0.,-1)
CCC      CALL SYMBOL (XXB,YYB,SIZE,IC,0.,-ICA)
      GO TO 1127
1122 NNN=0
      CALL SYMBOL (XXB,YYB,SIZE,IC,0.,-1)
C      CALL SYMBOL (-YYB,XXB,SIZE,IC,0.,-1)
      GO TO 1127
1124 IF ((VAR(I-1,J).GT.VISOBR).AND.(VAR(I-1,J+1).GT.VISOBR).AND.(IIB.EQ
1.1)) GO TO 1109
      IF ((VAR(I-1,J).LT.VISOBR).AND.(VAR(I-1,J+1).LT.VISOBR).AND.(IIB.EQ
1.1)) GO TO 1109
      IF ((VAR(I-1,J).GT.VISOBR).AND.(VAR(I-1,J+1).GT.VISOBR).AND.(IIB.EQ
1.2)) GO TO 1121
      IF ((VAR(I-1,J).LT.VISOBR).AND.(VAR(I-1,J+1).LT.VISOBR).AND.(IIB.EQ
1.2)) GO TO 1121
      GO TO 1125
1123 IIB=5
      IF ((VAR(I-1,J).GT.VISOBR).AND.(VAR(I-1,J+1).GT.VISOBR)) GO TO 1127
      IF ((VAR(I-1,J).LT.VISOBR).AND.(VAR(I-1,J+1).LT.VISOBR)) GO TO 1127
1125 DS= X(I-1,J+1)-X(I-1,J)
      DSS=DS*(VISOBR-VAR(I-1,J))/(VAR(I-1,J+1)-VAR(I-1,J))
      XXB= (X(I-1,J)+DSS)
      DN= Y(I-1,J+1)-Y(I-1,J)
      DNN=DN*(VISOBR-VAR(I-1,J))/(VAR(I-1,J+1)-VAR(I-1,J))
      YYB= (Y(I-1,J+1)-(DN-DNN))
      WRITE(6,1114) XXB,YYB,I,J,VISOBR,VAR(I-1,J),VAR(I-1,J+1),DS,DN
      IF (NNN.EQ.1) GO TO 1126
      ICA=2
      IF (IIB.EQ.5) ICA=1
      CALL SYMBOL (XXB,YYB,SIZE,IC,0.,-ICA)
      IF (IIB.EQ.5) GO TO 1121
      GO TO 1127
1126 NNN=0
      CALL SYMBOL (XXB,YYB,SIZE,IC,0.,-1)
C      CALL SYMBOL (-YYB,XXB,SIZE,IC,0.,-1)

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      IF(IIB.EQ.5) GO TO 1121
1127 CONTINUE
1130 CONTINUE
1128 CONTINUE
      NNN=1
      RETURN
      END
```

INPUT DATA

In the following, the different parameters used to specify the cases that can be computed using the computer program, will be explained, then a description in details of how to prepare the input data will be given.

Control Parameters for Computations

1. (a) Symmetric scroll cross section, $ISYM = 1$.
(b) Nonsymmetric scroll cross section, $ISYM = 0$.
2. The type of through flow profile is specified using the parameters IFG, IFREVO, and IPAP.
 - (a) $IFG = 1$, $IPAP = 0$, $IFREVO = 0$, for an arbitrary source distribution. In this case the source strength is fed as an input at all the interior mesh points.
 - (b) $IPAP = 1$, $IFG = 0$, $IFREVO = 0$, for a circular paraboloid source distribution.
 - (c) $IFREVO = 1$, $IPAP = 0$, $IFG = 0$, for free vortex source distribution.
 - (d) $IFG = 0$, $IPAP = 0$, $IFREVO = 0$, represents uniform source distribution.
3. Either compressible or incompressible flow solutions are obtained by specifying the value of the parameter ICOM. Compressible flow solutions specify $ICOM = 1$, and for incompressible flow case $ICOM = 0$.

How to Prepare the Input

The input is divided into seven sets, and is given in the following.

First Set (Fluid Properties), one card

READ: RG, GAMA, TO, VE
according to format (4F10.0)

Second Set (Scroll Geometry), one card

READ: M1, M2, DO, R1, B, H, R, RC
according to format (2I10, 6F10.0)

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Third Set (Control Parameters), one card

READ: ICOM, ISYM, IFG, IPAP, IFREVO
according to format (5I10)

Fourth Set (Numerical Parameters), one card

READ: ITMAX, EPSMAX, WO, WOP
according to format (I10, 3F10.0)

Fifth Set (Output Control Parameters), one card

READ: IP, IVPLOT, IPLT
according to format (3I10)

Sixth Set (Values for Velocity Potential Contour Plotting),

number of cards is equal to IPLT

READ: VISOBR
according to format (F10.0)

VISOBR Numerical values of the velocity potential
contours to be plotted as output.

Seventh Set (Arbitrary Source Distribution)

Is required only in the case of arbitrary source distribution, i.e., IFG = 1. The value of the source distribution $F(I,J)$ is read in DO loop according to format (8F10.0). The input data is fed starting from $I = 1$ to $I = M_3$, and marching in J direction from $J = J_L$, J_U as shown in Fig. 3a. (Ref. 1)

OUTPUT

The program output includes a printout of the pertinent flow properties at all the grid points every IP iteration and of two figures, one for the desired velocity potential contours as specified by IPLT and VISOBR and the second showing the velocity direction in the cross-sectional plane.

Samples of the program output are included in Ref. 1.

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